# THE PHILIPPINE
# JOURNAL OF SCIENCE

## VOLUME XV

JULY TO DECEMBER, 1919

WITH 64 PLATES AND 32 TEXT FIGURES



MANILA
BUREAU OF PRINTING
1920

168743

## CONTENTS

### No. 1, July, 1919

[Issued December 23, 1919.]



### No. 2, August, 1919

[Issued December 29, 1919.]

**No. 3, September, 1919**

[Issued January 4, 1920.]



**No. 4, October, 1919**

[February 27, 1920.]



**No. 5, November, 1919**

[March 1, 1920.]

**No. 6. December, 1919**

[March 30, 1920.]

THE PHILIPPINE
# JOURNAL OF SCIENCE

VOL. XV JULY, 1919 No. 1

## PHILIPPINE BEES OF THE GENUS NOMIA

By T. D. A. COCKERELL
*Of the University of Colorado*

The andrenid genus *Nomia* is widely distributed over the world, but is much more numerous in species in the Eastern than in the Western hemisphere. The species show such diverse characters that authors have at different times proposed to divide the genus into several genera and subgenera. It is doubtfully expedient, however, to recognize more than one genus, though most of the names proposed may properly be used in a subgeneric sense. The type of the genus, as Meade-Waldo has shown, is the Asiatic *Nomia curvipes* of Fabricius. This has colored tegumentary bands on abdomen, postscutellum unarmed, and the hind femora of the male greatly swollen and sharply toothed beneath. It may be considered typical of a group which in the Philippine fauna includes *N. thoracica*, *N. longitarsis*, *N. lusoria*, *N. strigata*, and *N. iridescens;* but none of these has the hind femora of the male as in *curvipes*. In *N. thoracica* these femora are swollen, but not toothed beneath.

*Hoplonomia* Ashmead resembles true *Nomia*, but has a bidentate process, or two teeth, on the postscutellum. The type is *N. quadrifasciata*, a Philippine species.

The following key will facilitate the separation of the Philippine species:

*Key to the Philippine species of Nomia.*

Abdomen pale red (Sulu Island) .......... dimidiata Vachal.
Abdomen not red .......... 1.
1. Antennæ and legs entirely dull ferruginous; female, 12.5 millimeters long (Palawan) .......... philippina Vachal.
   Antennæ and legs otherwise colored; or, if reddish, smaller species .......... 2.
2. Postscutellum bidentate or bispinose .......... 3.
   Postscutellum unarmed .......... 4.
3. Male with hind tibiæ, except a large black spot behind, and hind tarsi, yellowish .......... quadrifasciata (Ashmead).
   Male with hind tibiæ, except apical process, and hind basitarsi, black or brown .......... quadrifasciata notha Cockerell.

4. Abdomen with tegumentary bands, not covered with hair........ 5.
Abdomen without such bands, though the hind margins of segments may be reddish or testaceous........ 7.
5. Bands white........ **thoracica stantoni** (Ashmead).
Bands yellowish or red........ **longitarsis** Cockerell.
Bands green, sometimes suffused with red........ 6.
6. First abdominal segment without a band........ **iridescens** Smith.
First abdominal segment with a band........ **strigata** (Fabricius).
Like *strigata*, but hind legs modified (see description).
**lusoria** sp. nov.
7. Abdomen clavate (males)........ 8.
Abdomen not clavate........ 10.
8. Fifth ventral segment of abdomen of male with two red spots bearing black prominences........ **elongatula** Cockerell.
Fifth ventral segment not so........ 9.
9. First abdominal segment of male narrow and little punctured.
**lautula** sp. nov.
First abdominal segment broader and more distinctly punctured; larger species........ **levicauda** Cockerell.
10. Males........ 11.
Females........ 12.
11. Hind basitarsi pallid; hind femora enormously swollen.
**goniognatha** sp. nov.
Hind basitarsi dark........ **philippinensis** (Friese).
12. Rather large species, quite robust, with coarse punctures on mesothorax and excessively fine and dense punctures on abdomen; hind margin of first abdominal segment black........ **recessa** sp. nov.
Smaller species, with other characters........ 13.
13. Stigma small; area of metathorax almost or quite linear.
**philippinensis** (Friese).
Stigma large; abdomen of male clavate........ 14.
14. Second abdominal segment smooth and shining........ **levicauda** sp. nov.
Second abdominal segment rough and punctured........ **palavanica** Cockerell.

**Nomia quadrifasciata (Ashmead).**

*Hoplonomia quadrifasciata* ASHMEAD, ♂ (as "♀"), Journ. N. Y. Ent. Soc. 12 (1904) 4.

*Nomia quadrifasciata* (ASHMEAD) COCKERELL, Entomologist 48 (1915) 177.

LUZON, Manila (*W. A. Stanton*). MINDANAO, Dapitan (*Baker*).

The Dapitan specimen agrees with Ashmead's account, but is I think certainly only a variation of the commoner form, *Nomia notha*. Unless additional material from Manila shows better distinctive characters, I must conclude that there is only one distinct species involved.

**Nomia quadrifasciata notha (Cockerell ined.).**

*Nomia notha* COCKERELL, Entomologist 51 (1918) 112.

*Hoplonomia quadrifasciata* ASHMEAD, ♂ (not "♀"), Journ. N. Y. Ent. Soc. 12 (1904) 4.

*Nomia incerta* "GRIBODO" COCKERELL, Entomologist 48 (1915) 177 (not *incerta* Gribodo).

The receipt of genuine *Nomia incerta* from Java (Mount Salak, 2,500 feet, 3. 7. 09, *Bryant and Palmer*, United States National Museum), shows that this species (female) has the mesothorax with punctures of two sizes and the lobes of the postscutellar process very obtuse. The Philippine insect is clearly distinct, having the mesothorax with strong practically uniform punctures, and the lobes of the postscutellar process long and acute. The type, from Los Baños, is a female having the three abdominal bands apple green suffused with vermilion. All my material is from Baker.

LUZON, Manila (*Stanton*): Laguna Province, Los Baños and Mount Maquiling: Tayabas Province, Mount Banahao. MINDANAO, Dapitan and Davao. LEYTE, Tacloban. PALAWAN, Puerto Princesa. Related to *N. simplicipes* Friese.[1]

The following varieties look very distinct, but do not represent true races:

**Nomia quadrifasciata var. aurantia var. nov.**

*Female.*—Like *Nomia notha*, but abdominal bands rich orange, slightly tinged with apple green.

LUZON, Laguna Province, Mount Maquiling (*Baker*). Two specimens; one is *Baker 7469.*

**Nomia quadrifasciata var. viridans var. nov.**

*Female.*—Like *Nomia notha*, but abdominal bands very bright emerald green.

LUZON, Laguna Province, Los Baños (*Baker*).

**Nomia thoracica stantoni (Ashmead).**

*Paranomia stantoni* ASHMEAD, Journ. N. Y. Ent. Soc. 12 (1904) 4.
*Nomia thoracica stantoni* (ASHMEAD) COCKERELL, Entomologist 48 (1915) 177.

LUZON, Manila (*Stanton*): Laguna Province, Los Baños and Mount Maquiling (*Baker*). An insular race, smaller than typical *N. thoracica* Smith.

[1] *Nomia simplicipes* was described from Kaulun, near Hongkong. The male has the first segment of the abdomen green banded, and may not be conspecific with the female. As the specific name is derived from a character of the male, I herewith designate that as the type. This male is readily separated from *N. notha;* but a female *simplicipes* (agreeing with Friese's description) from Trong, Lower Siam, January–February, 1899 (W. L. Abbott; United States National Museum), is essentially like *N. notha*, except that the depressed part of the second abdominal segment is much broader (anteroposteriorly) in the middle.

Nomia longitarsis Cockerell.

*Nomia longitarsis* COCKERELL, Entomologist 49 (1916) 158.

The type is a male. The female (Mount Maquiling) is similar, with the usual sexual differences, the mesothorax more finely punctured, and the abdomen with much shallower and more feeble punctures. The stigma in both sexes is ferruginous.

LUZON, Laguna Province, Mount Maquiling (*Baker*).

Nomia longitarsis eboris var. nov.

*Male and female.*—Stigma black or reddish black; abdominal bands (except the first in female) clear opaque ivory color.

LUZON, Nueva Vizcaya Province, Imugan, male (type): Benguet Subprovince, Baguio, female. Both from Baker. Probably a subspecies, but without strong characters.

Nomia strigata (Fabricius).

*Andrena strigata* FABRICIUS, Ent. Syst. 2 (1793) 311.
*Nomia strigata* LEPELETIER, Hist. Nat. Ins. Hymén. 2 (1841) 291.
*Nomia iridescens* "SMITH," COCKERELL, Entomologist 48 (1915) 177 (not *iridescens* Smith).

I had formerly supposed [2] that the male of *Nomia iridescens* differed from the female in having the first five abdominal segments with colored bands, but I now find that there are males and females with (*strigata*) and without (*iridescens*) the band on first segment. Some specimens of *N. strigata*, as is usual in this group of *Nomia*, have bands which fail to assume the proper color, but then these bands are pallid or reddish, very different from the opaque black hind margin of the first segment in *iridescens*. It must be stated, however, that *strigata* and *iridescens* are extremely closely allied, and it is by no means certain that they are not forms of a single species. *Nomia quadridentata* Smith is based on a female that is evidently *strigata* and on a male of the *N. ellioti* group. The first and fullest description is that of the female, which is herewith designated as the type.

PALAWAN, Puerto Princesa. MINDANAO, Davao. NEGROS, Cuernos Mountains. All from Baker. The Philippine insect agrees with that from Java (Depok, Pelaboeam, Ratoe, Buitenzorg), collected by Bryant and Palmer (United States National Museum).

Nomia strigata var. ridleyi (Cockerell).

*Nomia iridescens* var. *ridleyi* COCKERELL, Ann. & Mag. Nat. Hist. VIII 5 (1910) 502.

[2] Ann. & Mag. Nat. Hist. VIII 5 (1910) 503.

MINDANAO, Davao (*Baker 7468*). Described from Singapore and also collected by Bryant and Palmer in Java (Buitenzorg, March, 1909; Depok). It is a color variety, doubtless alternating in Mendelian fashion with the typical form.

Nomia iridescens Smith.

*Nomia iridescens* SMITH, Journ. Proc. Linn. Soc. London, Zool. 2 (1857) 43.

LUZON, Laguna Province, Los Baños and Mount Maquiling. MINDANAO, Butuan and Davao. All from Baker. I have a female from F. Smith's collection, and the Philippine form agrees with it.

Nomia iridescens var. rhodochloa var. nov.

*Male and female.*—Abdominal bands bright yellowish green, suffused with vermilion.

MINDANAO, Dapitan (*Baker 7466*), male. NEGROS, Cuernos Mountains (*Baker*), female. The type locality is Dapitan.

Nomia lusoria sp. nov.

*Male.*—Like *N. strigata ridleyi*, but with third (as well as following) antennal joints clear red beneath; hind femora swollen, the upper side strongly convex; hind tibiæ greatly enlarged apically, the end reddish yellow, the inner side flattened and expanded apically, its margin broadly rounded and expanded; hind basitarsi pale reddish dusky apically.

PALAWAN, Puerto Princesa (from *Baker*).

Nomia elongatula Cockerell.

*Nomia elongatula* COCKERELL, Entomologist 48 (1915) 178.

LUZON, Laguna Province, Los Baños (type locality) and Mount Maquiling: Benguet Subprovince, Baguio. LEYTE, Tacloban. MINDANAO, Iligan. PALAWAN, Puerto Princesa. All from Baker.

Nomia levicauda sp. nov.

*Nomia elongata* "FRIESE," COCKERELL, Entomologist 48 (1915) 178 (not *N. elongata* Friese).

Finding that this group of *Nomia* included several distinct species, recognizable by the characters of the male abdomen, I wás led to reëxamine the species from Luzon which Friese had identified with his *N. elongata*, described from Java. Evidently the Philippine species is distinct, for although Friese's description of the male is brief, he states that the fifth ventral abdominal segment is bare, whereas in our insect it is hairy right

across. The female is very similar to that of *N. philippinensis,* but the area of metathorax is rather broad (anteroposteriorly) and irregularly plicate, and the abdomen is shiny. The stigma is very much larger than that of *philippinensis* and is of the same general type as that of *N. palavanica,* but dusky or with a dusky margin. The second abdominal segment is smooth and shining, whereas in *palavanica* it is rough and punctured.

LUZON, Laguna Province, Los Baños (type locality): Benguet Subprovince, Baguio. MINDANAO, Zamboanga. The females come from the following places: LUZON, Laguna Province, Mount Maquiling: Benguet Subprovince, Baguio. MINDANAO, Davao and Iligan. All from Baker. The series of females may include examples of the next species, which is perhaps not clearly separable in that sex.

Nomia laucula sp. nov.

*Male.*—Length, about 6 millimeters; slender, with the basitarsi cream color, their apices and the small joints of tarsi ferruginous; abdomen clavate, slender basally; the hind margins of segments with pale ocherous-tinted hair bands; face with pale golden hair; stigma large, dusky reddish. This species is so similar to *N. levicauda* that I thought it might be only a race, but it is certainly a distinct species, differing by the narrow and little-punctured first abdominal segment, the very densely punctured mesothorax, and especially the fifth ventral segment of abdomen, which has a pair of separate rounded elevations, covered with short, dark-tipped, more or less bifid bristles, instead of being hairy right across as in *N. levicauda.*

MINDANAO, Davao (*Baker*; two bear the numbers *7470, 7471*).

Nomia palavanica Cockerell.

*Nomia palavanica* COCKERELL, Entomologist 48 (1915) 178; 49 (1916) 158.

PALAWAN, Puerto Princesa (*Baker 3848*).

Nomia philippinensis (Friese).

*Nomia takauensis philippinensis* FRIESE, COCKERELL, Entomologist 48 (1915) 178.

LUZON, Laguna Province, Los Baños (type locality) and Mount Maquiling: Benguet Subprovince, Baguio: Tayabas Province, Malinao and Mount Banahao. MINDANAO, Davao. All from Baker.

Nomia goniognatha sp. nov.

*Male*.—Length, 7 to 8 millimeters; black, with the knees, tibiæ at apex, and tarsi except apex, yellowish ferruginous; pubescence pale ocherous, the mesothorax and scutellum with short, fulvous, mosslike hair; tongue very slender; eyes brown, strongly converging below; mandibles broad, pale testaceous, with the apex piceous and the swollen inner side of base broadly black, while the lower margin, beyond the middle, is conspicuously angular; vertex minutely rugose-punctate; area of metathorax very small, with five oblique striæ; tegulæ reddish testaceous, with piceous base; wings dusky, stigma testaceous, not large; hind femora enormously swollen, helmet-shaped; hind tibiæ short and broad, curved basally; abdomen finely punctured, the segments with pale fulvous hair bands; fourth ventral segment emarginate, with a median keel on a ferruginous band; fifth ventral with a strong dark keel produced to a claviform apex. The flagellum is bright ferruginous beneath, except at base and apex.

MINDANAO, Davao (from *Baker*).

In Bingham's table of Indian species this falls nearest to *N. aurifrons* Smith, to which are allied the later-described *N. aureobalteata* Cameron and *N. kangræ* Nurse. *Nomia aureobalteata* has a large metathoracic area, different legs, etc. *Nomia aurifrons* has testaceous legs. *Nomia kangræ* also differs in the legs and in other ways. The hair on the thorax in *N. goniognatha* recalls the much larger *N. thoraciea* or the Indian *N. ardjuna* Cockerell.

Nomia recessa sp. nov.

*Female*.—Length, about 9 millimeters or rather more; robust, black, with fine pale cinereous to white (on cheeks) hair, on mesothorax and scutellum thin and mainly fuscous, on vertex with a pale golden tint, on inner side of tarsi orange-ferruginous; hind tibiæ with hair mainly yellowish white, but on outer face dark fuscous; hind margin of first abdominal segment black, of the others broadly testaceous; no hair bands on apical margins of segments, but third segment with an even white basal fringe beneath the testaceous margin of second. Eyes dark reddish; mandibles dark reddish, black at base; antennæ black, the flagellum red apically, especially beneath; face broad, with thin cinereous hair; mesothorax densely and strongly punctured, but shining between the punctures; scutellum shining,

with large well-separated punctures; area of metathorax very small, but with strong ridges; tegulæ piceous with pallid margins; wings somewhat dusky, especially the apical marginal area; stigma dark castaneous; second submarginal cell receiving first recurrent nervure much beyond middle; legs entirely dark; abdomen dull, with excessively fine punctures; venter with reddish fulvous hair.

LUZON, Laguna Province, Mount Maquiling (*Baker*). Somewhat related to the Indian *N. basalis* Smith, but differing in the pubescence and the color of the wings.

**Nomia dimidiata** Vachal.

> *Nomia dimidiata* VACHAL, Miscellanea Entomologica 5 (1897) 8 of separate.

SULU ISLAND. One female in collection of Gribodo. Length, 6.5 millimeters.

**Nomia philippina** Vachal.

> *Nomia philippina* VACHAL, Miscellanea Entomologica 5 (1897) 7 of separate.

PALAWAN. One female in collection of Vachal. The author suggested that it was possibly a variety of *N. buddha* Westwood. The latter he had from Perak.

# THE METALLIC-COLORED HALICTINE BEES OF THE PHILIPPINE ISLANDS

By T. D. A. Cockerell

*Of the University of Colorado*

The subfamily Halictinæ, numerously represented in almost every part of the world, contains groups of species in which the surface of the body is black, brown, or yellowish, and others in which portions, at least, are metallic green or blue. The large genus *Halictus*, as generally understood, contains both metallic and nonmetallic species. In the Holarctic Region, Robertson has separated the metallic species as genera *Chloralictus* Robertson and *Seladonia* Robertson. He also recognizes, in North America, genera *Dialictus* Robertson (with only two submarginal cells) and *Paralictus* Robertson. How many such genera should be segregated from the old *Halictus*, it is hard to decide; and certainly the Robertsonian groups are less distinct than the genera commonly recognized among bees. The French entomologist Vachal went as far from current usage on the other side and not only refused to accept Robertson's genera, but threw into *Halictus* such genera as *Augochlora* and *Agapostemon*, almost universally considered distinct. The genus *Nomioides* Schenck, placed as a subgenus of *Halictus* by Dalla Torre, must be considered a distinct genus. Its members are small, usually with conspicuous yellow markings, almost perfectly imitating the American panurgine genus *Perdita*. Yet the venation is like that of *Halictus*, except that the marginal cell is narrowly truncate at the end. These bees are so unlike the species of *Halictus* that Cameron described several of them in *Ceratina*. Thus my *Nomioides comberi* from India must be called *N. punjabensis* (Cam.); for Meade-Waldo, on examining Cameron's types, found that his *Ceratina punjabensis*, published about four years earlier, was in fact my insect. It also appears that *Ceratina cerea* Nurse is to be called *Nomioides pulchella* Schenck or, according to the synonymy indicated by Alfken, *N. parvula* (Fabricius).

## Genus NOMIOIDES Schenck

Mesothorax green .......... 1.
Mesothorax steel blue, highly polished .......... 2.
1. Larger; abdomen with four entire yellow bands; mesothorax duller.......... dapitanellus Cockerell.
Smaller; abdomen with four (varying to two) lateral yellow marks, representing two widely interrupted bands; mesothorax more shining.......... valdezi Cockerell.

2. Larger (length, about 6 millimeters); abdomen black, without light markings. ........ melanogaster Cockerell.
   Smaller; abdomen marked with yellow. ........ valdezi Cockerell.

Nomioides dapitanellus Cockerell.

*Nomioides dapitanellus* COCKERELL, Entomologist 48 (1915) 107.

MINDANAO, Dapitan (*Baker 3161*).

Nomioides valdezi Cockerell.

*Nomioides valdezi* COCKERELL, Ann. & Mag. Nat. Hist. VIII 16 (1915) 487.

MINDANAO, Cagayan (*Baker 3670*), type locality. Also PALAWAN, Puerto Princesa (*Baker 8065*). In the Palawan males the mesothorax is usually steel blue, as in the type, but occasionally it is shining green. There are two females from Palawan. They are about 5.2 millimeters long; mesothorax green; scutellum with two large yellow spots; postscutellum with a yellow bar; abdomen with large oblique cuneiform yellow marks at sides of second and third segments.

Nomioides melanogaster Cockerell.

*Nomioides melanogaster* COCKERELL, Ann. & Mag. Nat. Hist. VIII 16 (1915) 487.

MINDANAO, Dapitan (*Baker 3162*).

## Genus HALICTUS Latreille

Females ........ 1.
Males ........ 4.
1. Mesothorax shining green; abdomen more or less purplish, green at base ........ subpurpureus sp. nov.
   Mesothorax dullish or granular or abdomen not purplish ........ 2.
2. Abdomen bright green ........ 3.
   Abdomen bluish green to olive green, but knees red; scape red at base. adonidiæ sp. nov.
   Abdomen dark, at most slightly greenish ........ pervarians sp. nov.
3. All the tibiæ red; scape red at base ........ taclobanensis Cockerell.
   Tibiæ black; scape all black ........ imuganensis sp. nov.
4. Abdomen black, slender ........ pervarians sp. nov.
   Abdomen metallic, not slender ........ 5.
5. Abdomen blue-green; legs mainly dark ........ cyanescens sp. nov.
   Abdomen yellowish green; tibiæ and tarsi clear ferruginous; base of scape ferruginous. ........ taclobanensis Cockerell.

Halictus taclobanensis Cockerell.

*Halictus taclobanensis* COCKERELL, Ann. & Mag. Nat. Hist. VIII 16 (1915) 488.

LEYTE, Tacloban (*Baker 3672*), type locality. LUZON, Mount Maquiling (*Baker*), female. MINDANAO, Davao (*Baker 8067*),

male; Cagayan (*Baker*), male. The male has the form of a female, as in certain Australian species, and the only conspicuous differences are in the longer antennæ and the caudal end of the abdomen.

Halictus subpurpureus sp. nov.

*Female.*—Length, about 6.5 millimeters; head very dark greenish, almost black; mandibles rufous at apex; clypeus feebly and sparsely punctured; supraclypeal area purplish; front with a sericeous luster; antennæ entirely black; mesothorax yellowish green, shining but not polished, without evident punctures; scutellum and hind margin of mesothorax glaucous green; area of metathorax large, with a very fine irregular reticulation; posterior truncation not sharply margined at sides; tegulæ dark brown; wings dusky, stigma black; first recurrent nervure meeting second transverse cubital; third submarginal cell narrow, quadrate, shaped nearly like the second; legs black; abdomen dorsally shining without bands and without evident punctures, the general color black, but the base greenish and the middle segments conspicuously suffused with purple; venter with large tufts of pale ocherous hair at the sides of the segments.

LUZON, Baguio, Benguet (*Baker*). Related to *H. pervarians*, but larger, with mesothorax more shining, and abdomen suffused with purple.

Halictus pervarians sp. nov.

*Female.*—Length, about 5.5 millimeters; head rather small, glaucous green; antennæ black; mesothorax and scutellum yellowish green, shining but not polished, without evident punctures; mesothorax with a median longitudinal depression; area of metathorax appearing dull and granular under a lens, the broadly rounded margin shining; tegulæ pale brown, dark at base; pleura bluish green; wings faintly dusky; stigma black; first recurrent nervure meeting second transverse cubital; third submarginal cell short; outer nervures of third submarginal and outer discoidal cells weakened; legs black; abdomen without bands, black with a greenish or brassy tint. Ventral segments of abdomen with lateral ocherous tufts as in *H. subpurpureus*.

Variety *a*. Front peacock green and supraclypeal area purple.

Variety *b*. Length, about 5 millimeters; tegulæ pale testaceous; tarsi ferruginous; stigma brown.

Variety *c*. Flagellum reddish beneath; mesothorax and scutellum very dark green; area of metathorax dark bluish. Stigma black as in the typical form.

*Male.*—Antennæ very long, black; face green; abdomen slender, black; tarsi, and anterior tibiæ in front, ferruginous. A male from Mount Banahao is considerably larger than one from Mount Maquiling.

LUZON, Mount Maquiling (*Baker*), type and varieties *a* and *b;* Imugan (*Baker*), variety *c;* Mount Banahao (*Baker*), male. Very variable, but apparently all one species. I have nine specimens before me.

Halictus imuganensis sp. nov.

*Female.*—Length, about 7 millimeters; bright golden green, the clypeus, mesothorax, and scutellum variably suffused with coppery red, or entirely green, or the clypeus peacock green; mandibles obscure reddish; face, front, mesothorax, and scutellum with a roughened granular surface; antennæ black; area of metathorax shining, with strong, irregular plicæ, forming a coarse irregular network; posterior truncation sharply defined at sides; thorax above with thin ocherous hair; tegulæ rufopiceous; wings very faintly dusky; stigma black; second submarginal cell large and broad, receiving first recurrent nervure at its apical corner; outer transverse cubital and recurrent nervures weakened; legs black; abdomen shining, without bands; a well-developed ventral scopa.

LUZON, Imugan (*Baker*), type locality. Mount Banahao (*Baker*): Baguio, Benguet (*Baker*). Five specimens are before me. Allied to *H. taclobanensis.*

Halictus adonidiæ sp. nov.

*Female.*—Length, about 6.5 millimeters; shining green, with dark tarsi, tegulæ rufotestaceous, and basal half of scape red. Closely allied to *H. imuganensis* Cockerell, differing in the color of scape, the bluish green (not brassy green) abdomen, the broader head, the scutellum and posterior half of mesothorax brilliantly shining, and the paler (brownish) stigma.

LUZON, Manila, Malate (*R. C. McGregor*), October 27, 1918, at flowers of *Adonidia merrillii* Beccari.

Halictus cyanescens sp. nov.

*Male.*—Length, a little over 5 millimeters; head, thorax, and abdomen blue-green; face and front, including clypeus, dull and granular; antennæ black; mesothorax granular; area of metathorax irregularly reticulate; posterior truncation sharply defined at sides; tegulæ testaceous; wings very faintly dusky,

stigma piceous; legs black; tarsi reddened apically; abdomen shining, without bands.

LUZON, Mount Banahao (*Baker*), two specimens. Very close to *H. imuganensis* and *H. taclobanensis*, having the robust form of a female in the male sex. The sexes of *H. taclobanensis* are colored alike, so I suppose the present insect to be distinct from *H. imuganensis*, from which it principally differs by being much smaller and quite differently colored.

The green *Halicti* of the Philippines fall into two very different groups or subgenera; one group consists of *H. subpurpureus* and *H. perrarians*, and the second consists of the other three species. The first is *Chloralictus* of Robertson; the second, with males resembling the females, may form a new subgenus **Homalictus**; type, *H. taclobanensis*.

# NEW RECORDS AND SPECIES OF PHILIPPINE MEMBRACIDÆ

By W. D. FUNKHOUSER

*Of the Zoölogical Laboratory, University of Kentucky*

ONE PLATE

Since the publication of a revised checklist of the Membracidæ described from the Philippine Islands[1] some very interesting new species and records have been received from Mr. R. C. McGregor, of the Bureau of Science, Manila, and from Prof. C. F. Baker, of the College of Agriculture, Los Baños, P. I., the study of which throws considerable light on the distribution and the range of certain species that are extremely rare.

Most of the material on which this paper is based was collected by Mr. McGregor in Antique Province, Panay Island, and on the small island of Batbatan, just off the west coast of Panay. Other valuable records received from Mr. McGregor were secured in Laguna and Rizal Provinces, Luzon Island, a few of them from the immediate environs of Manila. Mr. McGregor has secured the first data to be published on the food plants of a number of the species and has also collected for several species the nymphal forms, which have never been recorded. I am greatly indebted to Mr. McGregor and again to Professor Baker for the opportunity of studying this very interesting material.

Centrochares horrificus Westw. Plate I, fig. 1.

Add: *Habitat*.—PANAY, Antique Province, Culasi (*McGregor*).
*Host*.—*Acalypha stipulacea* Klotz.

A good series of nineteen specimens collected at Culasi by Mr. McGregor in 1918. Six males and six females were taken May 18, in the forest at an altitude of about 700 meters; one male and four females, on May 27, on shoots from a stub of *Acalypha stipulacea*; one female, on May 29, and one female, on June 15.

In spite of the long series of specimens of this species from the Islands which I have seen at various times, I am unable to

[1] Funkhouser, W. D., Notes on the Philippine Membracidæ, *Philip. Journ. Sci.* § D 13 (1918) 21–38.

recognize specific differences sufficient to admit *C. posticus* Buckton and *C. bucktoni* Distant as distinct species. It has already been noted in previous papers[2] that *C. horrificus* shows considerable variation in size and in color, some of which conforms to Buckton's descriptions and figures for his supposed new species. I am still unconvinced that they are distinct.

In addition to the adults recorded above, Mr. McGregor sends a nymph of this species, which is apparently in the third or fourth instar, taken with the adults at Culasi on May 27 and sent to me on a section of the leaf on which it was captured.

Since the immature form (Plate I, fig. 1) of this insect has never been noted in literature, it seems advisable to include a brief description, as follows:

Entirely yellow (specimen preserved in alcohol); length, 4 millimeters; width between humeral tubercles, 1.5; height from apex of clypeus to top of metopidium, 2.8; roughly sculptured; densely pubescent; pronotum showing a suprahumeral tubercle on each side and a median dorsal posterior process which extends backward over the mesothorax but does not reach metathorax.

Head longer than broad, roughly pubescent, without tubercles, ocelli not visible, eyes large.

Thorax distinctly divided into segments; prothorax rough, densely pubescent, metopidium perpendicular, pronotum showing two strong tubercles representing the suprahumeral horns, posterior process extending backward over mesonotum but not reaching metanotum; mesonotum with a small tubercle on each side of median line; wing pads well developed, extending to first abdominal segment; entire thorax yellowish and densely pubescent with grayish hairs.

Abdomen showing nine segments, each segment slightly nodulate above with tufts of bristly hairs and extended ventrocaudad at lateral margin with edges of segment pilose; anal tube short, blunt, slightly upraised.

Legs flattened, first two pairs somewhat foliaceous, very densely pubescent; tarsi well developed, three joints distinct; claws swollen and heavy.

Judging from the development of the pronotal tubercles, the length of the wing pads, and the invisible ocelli, this nymph is in its third instar. It was attached by the first pair of legs to the midrib of the leaf in a position for molting.

[2] Funkhouser, Philip. Journ. Sci. § D 10 (1915) 370 and 13 (1918) 23.

Pyrgonota bifoliata Westw.

Add: *Habitat.*—PANAY, Antique Province, Culasi (*McGregor*).

Eighteen specimens collected at Culasi by Mr. McGregor in 1918. Two specimens were taken in the forest at an altitude of about 700 meters on May 18, one on May 24, three on May 29, one on May 30, ten on June 15, and one on June 20.

This species has often been figured to represent the grotesque and unusual development of the pronotum in the Membracidæ and usually stands as a "show species" in museums. It is unusual to find so large a series as the present material offers.

Pyrgonota bifurca Stål.

Add: *Habitat.*—LUZON, Baguio, Benguet Subprovince (*Baker*).

This is the first record of this species since its original description by Stål in 1870.[3] Stål's description is very detailed and closely fits the single specimen from Baguio. The lateral carina on the posterior process of the pronotum is not as distinct as might be expected from the original description but is rather irregular throughout and obsolete at the extremity. In all other respects, however, the characters seem identical. The specimen before me bears Professor Baker's duplicate No. 7657.

Pyrgonota semperi Stål. Plate I, figs. 2 and 3.

Add: *Habitat.*—PANAY, Antique Province, Culasi (*McGregor*).
*Host.*—*Acalypha stipulacea* Klotz.

It has been a great pleasure to be able at last to recognize this species from three specimens collected by Mr. McGregor at Culasi—one on May 28, one on May 29, and one on June 30, 1918.

The species has never been recognized since its original description;[4] this description is very meager, being merely four lines of Latin comparing the type with *P. bifurca*. However, I feel confident that the Culasi material represents the insect which Stål described. It has the pale marking on the posterior process which is the chief distinctive character according to Stål, and the measurements exactly agree with those of the type. On account of the fact that the original description is so brief and the fact that the species has never been figured, I am including a more complete list of its characters as follows:

Very dark brown, almost black, coarsely and evenly punctate, sparingly pubescent with grayish hairs; pronotal horn long,

[3] Oef. Kongl. Vet.-Akad. Forhandl. No. 7 (1870) 731.

[4] Loc. cit.

erect, subcylindrical, narrowing toward the apex, apex forked, the prongs of the fork twisted and broadly foliaceous; posterior process long, slender, slightly elevated behind the middle, marked with a pale median line for basal two-thirds; tegmina entirely very dark brown or black. (Cf. Stål: "processu postico thoracis ante medium macula pallescente notato, pone medium quam anterius altiore, tegminibusque totis piceis.")[5]

Head longer than broad, foliaceous, roughly sculptured, dark brown, coarsely punctate, finely pubescent; base sinuate, highest on either side of median suture; sutures distinct, elevated; eyes prominent, brown; ocelli very prominent, opalescent, shining, much farther from each other than from the eyes and situated well above a line drawn through centers of eyes; inferior margins of genæ sinuate, foliaceous, sloping downward abruptly to clypeus; clypeus foliaceous, distinctly trilobed, two smooth longitudinal striæ down middle, finely punctate, sparingly pubescent, tip pilose.

Pronotum uniform dark brown or black except narrow yellowish line on basal two-thirds of posterior process, roughly punctate, sparingly pubescent with grayish hairs on upper parts, very densely pubescent and tomentose just before humeral angles; humeral angles not prominent, obtuse; anterior pronotal horn erect, long, slender, turriculate, heavy at base, gradually becoming narrower toward apex, bearing a distinct median carina in front, two or three irregular lateral ridges and a sharp posterior ridge which is strongly toothed, the teeth becoming smaller and closer together as they approach the posterior process, apex of horn forked, forks bent backward, with a slight extension of the median column between the two prongs of the forks; prongs of the fork as seen from the front widely separated at their bases, then approaching each other and nearly touching at their tips, much compressed laterally below, somewhat twisted and triquerate at apex, apical ends obliquely and sinuately truncate; posterior process long, slender, sinuate, highest behind middle, basal two-thirds marked with narrow yellowish vitta, sharply carinate and denticulate above, tip depressed and extending somewhat beyond lateral angles of tegmina.

Tegmina opaque, dark brown or black, strongly punctate and coriaceous in basal and costal regions, a very small pale spot at internal angles, tips long and acute, five apical and three discoidal areas.

[5] Loc. cit.

Sides of mesothorax and metathorax toothed, densely tomentose with white hairs; undersurface of body and abdomen brown.

Legs entirely yellow; tibiæ flattened and minutely spined; claws ferruginous.

Length, including tegmina, 7 millimeters; width between humeral angles, 2; height of pronotal horn from humeral angles to tips, 10.

Leptocentrus reponens Walk.

Add: *Habitat.*—LUZON, Manila: Rizal Province, Montalban: Laguna Province, Paete. PANAY, Antique Province, Tibiao, Culasi, and Lipata. (*McGregor.*)

*Host.*—*Blumea balsamifera* (L.) DC.; *Semecarpus cuneiformis* Blanco; *Acalypha wilkesiana* Muell.-Arg.; *Mallotus moluccanus* (L.) Muell.-Arg.; *Hibiscus rosa-sinensis* L.

An excellent series with records of the host plants, collected as follows: Two from Montalban taken February 22, 1918, on *Blumea balsamifera* and *Semecarpus cuneiformis;* one from Manila, February 1, 1917; three from Manila, February 5, 1917, on *Mallotus moluccanus;* one from Manila, February 5, 1917, on *Acalypha wilkesiana;* one from Manila, February 10, 1917, on *Hibiscus rosa-sinensis;* one from Lipata, July 9, 1918, on "a spiny shrub;" two from Paete, March 6 and 13, 1917; five from Tibiao, May 14, 1918; four from Culasi taken in the forest at about 700 meters' elevation on May 18, 1918; two from Culasi, May 20, 1918; one from Culasi, June 3, 1918; one from Culasi, June 19, 1918, and two from Culasi, July 24, 1918.

The above data for hosts are the first ever recorded for this species, and all of the localities are new.

Mr. McGregor's field notes record the interesting fact that this species was not attended by ants.

Leptocentrus leucaspis Walk.

Add: *Habitat.*—Antique Province, Batbatan Island (*McGregor*).

One male taken on Batbatan Island on June 30, 1918.

Tricentrus robustus Funkh.

Add: *Habitat.*—PANAY, Antique Province, Tibiao, Culasi, and Flores (*McGregor*).

*Host.*—*Acalypha stipulacea* Klotz.

A series of nine specimens, all females, collected in Panay in 1918 as follows: One taken in the forest at Culasi at 700 meters'

elevation on May 18; one from Culasi collected on shoots from a stub of *Acalypha stipulacea* on May 27; three from Culasi, June 1; one from Culasi, June 20; one from Culasi, July 14; one from Tibiao, May 11; one from Flores, June 7.

Tricentrus convergens Walk.

Add: *Habitat.*—LUZON, Manila. PANAY, Antique Province, Culasi. (*McGregor.*)

*Host.*—*Mallotus moluccanus* (L.) Muell.-Arg.; *Acalypha wilkesiana* Muell.-Arg.

Six specimens collected as follows: Two females and one male taken at Manila, February 14, 1917; one female collected at Manila, February 5, 1917, on *Mallotus moluccanus;* one male from Manila, April 5, 1917, on *Acalypha wilkesiana;* one female from Culasi taken in the forest at an altitude of 700 meters on May 18, 1918.

Tricentrus attenuatus Funkh.

Add: *Habitat.*—PANAY, Antique Province, Culasi (*McGregor*).

Two males from Culasi, one taken in the forest on May 18, 1918, and one at a lower elevation on July 14, 1918.

*Tricentrus attenuatus* was described from a male, and all of the specimens which I have seen of this species have been of the same sex. This fact makes me suspicious that perhaps we have here the opposite sex of some other species described from female material only. It will be of interest to discover an undoubted pair of this species.

Tricentrus capreolus Walk.

Add: *Habitat.*—LUZON, Laguna Province, Paete, Sarai barrio (*McGregor*).

One female collected on March 19, 1917.

Tricentrus fairmairei Stål. Plate I, fig. 4.

Add: *Habitat.*—LUZON, Rizal Province, Montalban: Laguna Province, Paete. PANAY, Antique Province, Culasi. (*McGregor.*)

*Host.*—*Solanum verbascifolium* L.; *Eugenia calubcob* C. B. Rob.

*Attendant ants.*—*Polyrhachis* (*Myrmhopla*) *dives* Smith.

A good series of specimens of this species has been received together with nymphs and attendant ants. Five specimens were collected at Paete on March 18, 1917; eighteen were taken

at Montalban, February 22, 1918, on fruit heads of *Solanum verbascifolium* and on young shoots of *Eugenia calubcob;* and one specimen was collected in the forest of Culasi near a 700-meter elevation.

The nymphs (Plate I, fig. 4) were all collected at Montalban on February 22, 1918, on *Eugenia calubcob* and are all in the last instar. Since the immature form of this insect has not been previously recorded, a brief description is given as follows:

Brilliant yellow, marked with black; length, 5 millimeters; width, 3; smooth, shining, not punctate, very sparingly pubescent, head tuberculate above; pronotum with three strong spines, one on median dorsal line and one on each side; mesonotum with one strong median dorsal spine; abdomen with a strong lateral spine on each segment except the last; wing pads reaching the first abdominal spine.

Head much broader than long, bright yellow, smooth, shining, impunctate, only lightly pubescent at margins; base strongly elevated at middle and bearing a strong tubercle on each side of median line; eyes very prominent, produced laterally, jet black; ocelli not visible; sutures distinct; inferior margins of genæ almost transverse; clypeus longer than broad, extending for more than half its length below the inferior margins of the genæ, tip rounded and somewhat pilose.

Thorax distinctly divided into prothorax, mesothorax, and metathorax, not punctate, sparingly pubescent, shining, jet black in front, bright yellow on sides and behind spines; humeral angles very prominent, auriculate; pronotum having three strong spines, one on median dorsal line pointing upward and slightly backward, one on each side above humeral angle projecting upward and outward, an extension of dorsum behind median spine extending to the spine of the mesonotum; mesonotum with strong central spine at posterior margin; metanotum without spine, bright yellow above, jet black at sides; wing pads very well developed, reaching backward as far as the first lateral spine of the abdomen.

Abdomen broad, flattened dorsoventrally, bearing seven distinct segments, of which the first six have strong lateral spines extending directly outward, these spines gradually becoming longer from before backward; entire abdomen shining, impunctate, not pubescent, black above, yellow on sides, apex strongly curved upward; anal tube long, upraised, wider at base than at tip.

Legs and undersurface of body shining luteus.

The form as above described is very apparently in the fifth instar and about ready for the final molt.

Mr. McGregor's field notes on *Tricentrus fairmairei* state that both adults and nymphs are attended by black ants of which he sends specimens. These ants have been determined by Prof. W. M. Wheeler, of Harvard University, as *Polyrhachis* (*Myrmhopla*) *dives* Smith. I am again indebted to Professor Wheeler for his kindness in making these determinations.

Tricentrus acuticornis sp. nov. Plate 1, figs. 5 and 6.

Near *Tricentrus convergens* Walker but differing in size and particularly in the formation of the suprahumeral horns. On superficial examination I had placed these specimens with the males of *T. convergens*, which they closely resemble in general appearance; but further study shows them to belong to a distinct species.

Small, dark brown with large white tomentose patches behind each eye, closely punctate, densely pubescent; suprahumeral horns acute, slightly diverging, longer than the distance between their bases, not at all flattened; posterior process straight, extending just beyond internal angles of tegmina; tegmina smoky hyaline; hind trochanters armed with strong spines.

Head a little broader than long, subquadrangular, black, the fine punctures almost entirely hidden by the dense silvery pubescence; base weakly sinuate, rounded, highest above ocelli; eyes very prominent, gray, extending laterad half as far as the humeral angles; ocelli large, pearly, about equidistant from each other and from the eyes and situated above a line drawn through centers of eyes; inferior margins of genæ weakly sinuate, extending slightly downward from eyes to about middle of clypeus; clypeus longer than wide, densely pubescent, extending for somewhat more than half its length below inferior margins of genæ.

Pronotum black, closely punctate, densely pubescent; metopidium perpendicular, broader than high, slightly convex; suprahumeral horns straight, triquerate, acute, longer than the distance between their bases, extending upward, forward, and slightly outward, tips somewhat recurved; humeral angles prominent, auriculate; dorsum almost straight, sloping downward from suprahumeral horns to posterior process; posterior process short, acute, sharply carinate above, tip triquerate, sharp, extending just beyond internal angles of tegmina; median carina percurrent, faint on metopidium, strong on posterior process.

Tegmina much wrinkled, smoky hyaline; base coriaceous, black, punctate and pubescent; tip marked with narrow brown spot at costoapical angle; five apical cells.

Sides of thorax densely white tomentose; undersurface of thorax black; abdomen dark brown; legs ferruginous with bases of femora darker; tarsi ferruginous; claws brown; hind trochanters very prominently armed with strong teeth.

Length from front of head to tips of tegmina, 5.3 millimeters; width between tips of suprahumeral horns, 3.

PANAY, Antique Province, Culasi (*McGregor*), 3 females.

Type, a female, in my collection.

Described from three females from Culasi, one taken May 18, 1918, and two taken May 27, 1918. Type and two paratypes in my collection.

**Sipylus dilatatus** Walk.

Add: *Habitat.*—LUZON, Manila: Rizal Province, Pasig. PANAY, Antique Province, Culasi. (*McGregor.*)

*Hosts.*—*Phyllanthus reticulatus* Poir.; *Acalypha stipulacea* Klotz.

Seven specimens collected as follows: One male and one female taken at Manila in April, 1917; one male and two females taken at Pasig, February 17, 1918, on *Phyllanthus reticulatus;* two females taken at Culasi, May 27, 1918, on shoots from a stub of *Acalypha stipulacea.* Mr. McGregor's field notes on this species state that the insects were solitary and were not attended by ants. With the specimens of this species now available for study, it appears that the males average considerably smaller and darker than the females but show the same characteristic broadened pronotum and the nodulate veins on the tegmina.

**Gargara varicolor** Stål.

Add: *Habitat.*—LUZON, Manila: Rizal Province, Montalban (*McGregor*).

*Hosts.*—*Acalypha wilkesiana* Muell.-Arg.; *Solanum verbascifolium* L.

*Attendant ants.*—*Polyrhachis* (*Myrmhopla*) *dives* Smith.

A fine series of this species, of which three specimens were collected at Manila, February 14, 1917; twenty-three at Manila, April 5, 1917, on *Acalypha wilkesiana;* and ten at Montalban, February 22, 1918, on fruit heads of *Solanum verbascifolium* Linn.

This species, according to Mr. McGregor's notes, is gregarious and is attended by black ants of which a number have been received. Professor Wheeler determines these ants as the same species [*Polyrhachis* (*Myrmhopla*) *dives* Smith] as those found with *Tricentrus fairmairei* Stål.

Gargara nitidipennis Funkh.

Add: *Habitat*.—LUZON, Laguna Province, Paete. PANAY, Antique Province, Culasi. (*McGregor*.)

One male and eight females taken at Paete on March 29, 1917, and one female taken at Culasi on May 29, 1918.

This species shows more variation in size than any other species from the Islands, but I can find no specific differences between the large and the small forms.

Gargara nigrofasciata Stål.

Add: *Habitat*.—LUZON, Laguna Province, Paete (*McGregor*).

Three males and one female from Paete. It has previously been recorded [6] that this species also shows considerable variation. The specimens from Paete are larger and darker than the type described by Stål, but agree with specimens from Mindanao collected by Professor Baker.[7]

Gargara tuberculata Funkh.

Add: *Habitat*.—LUZON, Manila (*McGregor*).

One female collected at Manila on April 5, 1918.

Gargara pygmaea Walk.

Add: *Habitat*.—PANAY, Antique Province, Culasi (*McGregor*).

*Host*.—*Acalypha stipulacea* Klotz.

One female taken at Culasi, May 27, 1918, on shoots from a stub of *Acalypha stipulacea*.

Gargara rugonervosa Funkh.

Add: *Habitat*.—PANAY, Antique Province, Culasi (*McGregor*).

*Host*.—*Croton leiophyllus* Muell.; *Acalypha stipulacea* Klotz.

One male taken May 18, 1918, on *Croton leiophyllus*; and another male taken May 27, 1918, on *Acalypha stipulacea*. Both specimens are from Culasi.

[6] Philip. Journ. Sci. § D 10 (1915) 398. [7] Ibid. 13 (1918) 32.

Gargara pulchripennis Stal.

Add: *Habitat.*—PANAY, Antique Province, Culasi (*McGregor*).

*Host.*—*Acalypha stipulacea* Klotz.

One male collected May 27, 1918, on shoots from a stub of *Acalypha stipulacea.*

Gargara grisea sp. nov.

Very near *G. tuberculata* and may be only a variety of that species. It may be at once recognized by the very dense gray pubescence which is quite distinctive.

Large, heavy-bodied, light brown, but so covered with dense grayish white pubescence that the body color and the punctation are almost entirely hidden; metopidium convex; posterior process just reaching internal angles of tegmina; tegmina translucent, base and veins densely pubescent with grayish white hairs, veins strongly tuberculate.

Head broader than long, densely tomentose with white pubescence; base regularly sinuate, highest above ocelli; eyes large, prominent, grayish brown; ocelli large but not prominent on account of the dense pubescence, glassy, about equidistant from each other and from the eyes and situated slightly above a line drawn through centers of eyes; inferior margins of genæ almost straight; clypeus longer than wide, densely tomentose with white pubescence, extending for more than half its length below inferior margins of genæ.

Pronotum densely pubescent with grayish white hairs which are thicker near base of head and around humeral angles; metopidium strongly convex; humeral angles large and auriculate; dorsum arcuate; median carina strongly percurrent; posterior process short, heavy, blunt, sharply carinate above, tip just reaching internal angles of tegmina.

Tegmina translucent, not clearly hyaline; base coriaceous and densely pubescent; veins pubescent and strongly tuberculate; tegmina with five apical areas; hind wings with three apical areas.

Sides and undersurface of thorax densely white tomentose; abdomen brown, densely pubescent with white below, segments bordered with white above.

Femora dark brown, smooth; tibiæ ferruginous and spined; tarsi ferruginous; claws brown; hind trochanters unarmed.

Length, 4 millimeters; width between humeral angles, 2.2.

LUZON, Manila (*McGregor*), a pair.

Type, a female.

Described from a pair collected at Manila, the female on February 11, 1917, and the male on April 5, 1917. The male is slightly smaller than the female but shows the same characteristic grayish white pubescence. Type and allotype in my collection.

Cryptaspidia tagalica Stål.

Add: *Habitat.*—PANAY, Antique Province, Culasi (*McGregor*). One female taken June 1, 1918.

Cryptaspidia elevata sp. nov. Plate I, fig. 7.

Recognized by the thick, elevated posterior process and the auriculate humeral angles.

Black, punctate, hairy; no suprahumeral horns; humeral angles projecting as broad rounded lobes; scutellum entirely concealed; posterior process suddenly turned upward at tip; tegmina marked with black.

Head wider than long, black, densely covered with long yellowish hairs which entirely conceal the punctation; base weakly sinuate; eyes large, brown; ocelli prominent, pearly, a little farther from each other than from the eyes and situated slightly above a line passing through centers of eyes; clypeus wider than long, oval, extending only a little below the rounded outline of the inferior margins of the genæ, tip broadly rounded and hairy.

Pronotum black, punctate, thickly covered with long, yellowish hairs; metopidium very convex, rounded, wider than high, slightly flanged at inferior margin; humeral angles produced into broad earlike lobes rounded at tips; suprahumeral horns absent; posterior process short, heavy, much depressed at base, suddenly elevated at apex to form a heavy flattened spine, tip suddenly acute, flattened laterally and having carinæ above, below, and in the center of each side and reaching just beyond the internal angles of tegmina.

Tegmina closely impinging on lateral margins of pronotum; smoky hyaline, base and basal fourth of costal margin black and punctate; faint brown band across center of tegmen below internal angle, most distinct at costal edge.

Undersurface of body black and very hairy. Posterior trochanters unarmed. Legs uniform brown; tibiæ armed with long, thin, spinous hairs, distal ends with black spines.

Length, 7 millimeters; width between tips of humeral angles, 3.8.

LUZON, Benguet Subprovince, Baguio (*Baker*).

Type, a female.

**Cryptaspidia longa** sp. nov. Plate I, fig. 8.

Very long-bodied, narrow, black, closely and coarsely punctate, sparingly pubescent; posterior process not reaching internal angles of tegmina; tegmina smoky hyaline with very large black veins; scutellum entirely hidden; trochanters unarmed.

Head wider than long, subtriangular, black, weakly punctate, pilose, convex, median suture deeply depressed; base almost straight; eyes large, prominent, black with brown inner borders; ocelli prominent, translucent, yellowish, situated on broad elevations, about equidistant from each other and from the eyes and situated about on a line drawn through centers of eyes; inferior margins of genæ arcuate; clypeus slightly longer than broad, much deflexed, black, punctate, pilose with long golden hairs, tip rounded.

Pronotum entirely black, coarsely punctate, sparingly pilose with long golden hairs; median carina percurrent but weak; humeral angles not prominent, triangular; metopidium strongly convex; dorsum nearly straight; scutellum entirely concealed but present; posterior process short, straight, somewhat flattened, acute, tip sharp and not reaching the internal angles of the tegmina.

Tegmina very long, smoky hyaline, wrinkled; base coriaceous, black, punctate and pubescent; veins very strong, heavy, black, sparingly pilose; tips of tegmina extending well beyond apex of abdomen.

Sides and undersurface of thorax black, densely pilose with long golden hairs; abdomen very long, entirely black, densely pilose below; ovipositor smooth, black, shining, sparingly pubescent; legs ferruginous, tibiæ tinged with darker, tarsi and claws brown, hind trochanters without teeth.

Length, 8.2 millimeters; width, 3.

LUZON, Benguet Subprovince, Baguio (*Baker*).

Type, a female.

# ILLUSTRATIONS

## PLATE I

FIG. 1. *Centrochares horrificus* Westwood, nymph.
2. *Pyrgonota semperi* Stål, lateral outline.
3. *Pyrgonota semperi* Stål, front view of apex of pronotal horn.
4. *Tricentrus fairmairei* Stål, nymph.
5. *Tricentrus acuticornis* sp. nov., lateral outline.
6. *Tricentrus acuticornis* sp. nov., frontal outline.
7. *Cryptaspidia elevata* sp. nov., lateral outline.
8. *Cryptaspidia longa* sp. nov., lateral outline.

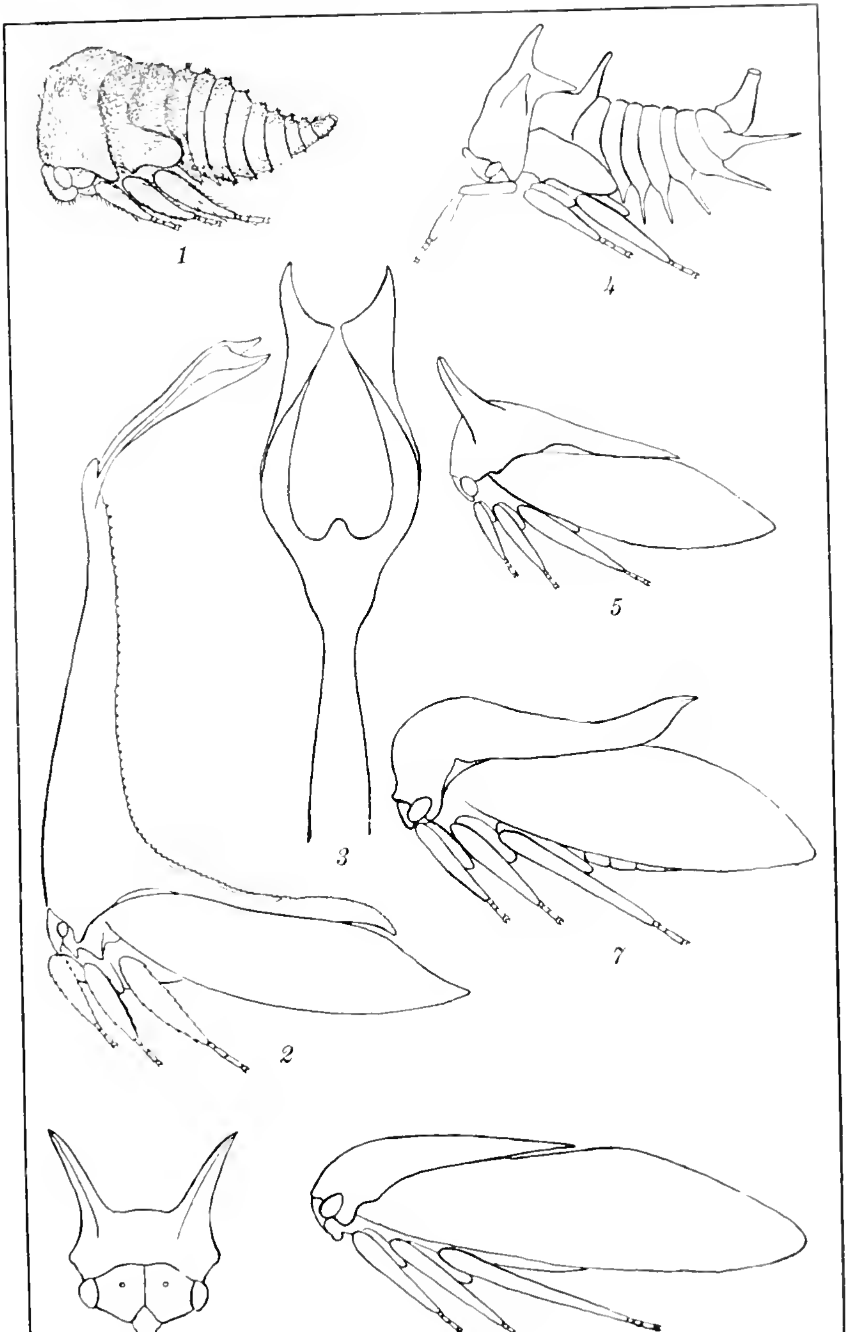



PLATE I. PHILIPPINE MEMBRACIDÆ.

# OSTEOLOGICAL AND OTHER NOTES ON THE MONKEY-EATING EAGLE OF THE PHILIPPINES, PITHECOPHAGA JEFFERYI GRANT

By R. W. Shufeldt

*Major, Medical Corps, United States Army, Washington, D. C.*

ELEVEN PLATES

Some time during the latter part of March, 1918, the captive specimen of the monkey-eating eagle of the Philippines (*Pithecophaga jefferyi* Grant), of the botanic garden of Manila, died, and the dead bird was immediately sent to the Bureau of Science, Manila. In his letter to me of April 1, 1918, Mr. McGregor stated that from this material he—

got a good skin—the first! in our collection, although we have a poor mounted specimen. The bones are being cleaned. They will lack the feet, the skull, and the ends of the wings. However, I shall supply a head and a foot from another specimen, so that the thing is nearly complete. The description of this should make a good paper, especially if you can lay hands on bones of the harpy eagle and other related genera.

All this material was received by me in the summer of 1918; and it was in excellent condition. I prepared and photographed the specimens myself. Later, the division of birds of the United States National Museum kindly loaned me certain skeletons, with which I intended to compare the bones of *Pithecophaga jefferyi*. These consisted of an imperfect skull of *Morphnus guianensis* (Daudin), adult (No. 18468); a complete skeleton of an adult *Thallasoaëtus pelagicus* (Pallas), collected by Paul L. Jouy in Korea (No. 18222); an *Aquila chrysaëtos canadensis* (Gmelin), female, adult, complete and disarticulated (No. 18802); a complete, disarticulated skeleton of *Gypaëtus barbatus* (Linnæus) (No. 17834); a complete skeleton, disarticulated, of *Haliæetus leucocephalus* (Linnæus), adult (No. 19278); and, finally, an incomplete skeleton of the harpy eagle, *Thrasaëtos harpyja* (Linnæus), adult (No. 225806). The last-named specimen lacked the skull. This bird was, during life, for several years one of the ornaments of the bird collection of the National Zoölogical Park at Washington. The skull was probably left in the skin. Subsequently I endeavored to obtain a skull of this species from the

Academy of Natural Sciences of Philadelphia, but was unable to do so.

It is very much to be regretted that a skull of the harpy eagle is not at hand for comparison with that part of the skeleton of *Pithecophaga*. Probably there is not a cleaned skull of the harpy eagle in the United States—adult, subadult, or young. This is invariably the case with respect to any bird before a glut takes place in museums and private collections of birds; the skulls are left in the skins!

THE CRANIUM, MANDIBLE, AND ASSOCIATED BONES OF PITHECOPHAGA

It matters but little from what point of view we may regard the cranium of this great eagle, the fact will at once be appreciated that at least two of its characters are so pronounced and so characteristic of the species that to confuse this part of the skeleton with the cranium of any other known eagle would be quite out of the question. In the first place, the lacrymal bones and their accessory outer pieces are of great size, while a still more conspicuous character is to be seen in the size and form of the osseous superior mandible; this is powerfully hooked, with cultrate tomia. It is transversely compressed almost to the last degree, the transverse diameter at the base beneath being slightly less than 2.5 centimeters, while the vertical height at the same point measures nearly 4 centimeters. Measured mesially below, it has a length of about 5.02 centimeters. Either narial aperture is very large, and these openings do not communicate through and through; anteriorly either one merges into the general surface of the side of the beak, while posteriorly greater depth is present, and the surrounding margin is sharp and triangular in outline; the apex of the triangle is posterior and above (Plate I, fig. 1).

Turning to the large lacrymals mentioned above, their form and proportions are well shown in the illustration (Plate I, fig. 2), while the descending limb is portrayed on the same plate. As is the case with so many large raptorial birds, these lacrymal bones, in adult life, do not fuse with the frontal and nasal upon either side nor with the large, subtriangular accessory piece supported at the outer end of each (fig. 2). The descending orbital limb of a lacrymal is constricted superiorly, anteroposteriorly flattened below, while it is broader and concaved in front from above downward. This part of a lacrymal does not come in contact either with the small, thin pars plana within or with the zygoma below.

Passing again to the dorsal aspect of the cranium, it will be observed, in the craniofacial region, that a considerable depression or concavity is present in the median area; posterior to this the frontal region is broad and flat, with the superior orbital margin cultrate. As in most eagles, the broad cranial vault is rounded and smooth, being marked only by the wonderfully fine, rambling, anastomosing lines that in life harbor the vessels of that region. I find these very well marked in the cranium of a white-headed eagle (*Haliæetus leucocephalus*) (Plate II, fig. 1) where, likewise, the depression in the craniofrontal region is pronounced. Throughout the diurnal Raptores, this character varies to some degree for the species. It is fairly well marked in the cranium of *Morphnus guianensis;* and several of the cranial characters thus far described in the cranium in *Pithecophaga* are more or less in agreement with the corresponding ones in this bird (Plate II, fig. 3). This in no way takes size into consideration, for *Morphnus* is not more than half the size of the monkey-eating eagle while, in a way, it does refer to the marked craniofacial depression, the lacrymals, and the general form of the osseous superior mandible. No other parts whatever have been seen or examined by me, and even the remainder of this cranium is very imperfect. When the material was selected for me at the United States National Museum, in addition to those designated by myself, this imperfect cranium of *Morphnus* was included.

In *Gypaëtus barbatus* a lacrymal does not support a free distal piece as in some eagles, while the superior outstanding portion is to a degree elongate and to some extent twisted upon itself. This bird has considerably more eagle in its skull, and in the rest of its skeleton for that matter, than it has vulture. However this may be, it has no special affinity with *Pithecophaga*, in so far as its skeleton would seem to indicate; and it is very much to be doubted that any of the rest of its morphology would point to any such relationship. Nothing would be gained, therefore, by a comparison of the skeletal characters of these two birds, beyond a demonstration of the fact that they possess no near relationship; and this much is evident to any expert avian osteologist at a glance. This in no way applies, however, to such a form as the big eagle of Korea, *Thallasoaëtus pelagicus*, a complete disarticulated skeleton of which (No. 18222, United States National Museum) I have before me. Paul L. Jouy collected it in that country many years ago. In its cranium it exhibits all the aquiline characters of an average eagle, including

the accessor pieces on the lacrymals. Upon summing up its cranial characters, however, it is very evident that it is not as nearly related to *Pithecophaga* as is the golden eagle (No. 18802, United States National Museum) (Plate II, fig. 2).

All eagles thus far examined by me possess, upon lateral aspect of the cranium, a deep, rounded, separated crotaphyte fossa; a large, squarish postfrontal process; and a squamosal projection. This does not show very well in fig. 1 of the present memoir, due to faulty lighting of the skull; nor do we, in the same figure, gain any idea of the enormous capacity and depth of the orbit that exists in the cranium of our subject. Indeed, it measures as much as 3 centimeters from the lower edge of the postfrontal process to the edge of the subcircular vacuity in the interorbital septum in *Pithecophaga*. This vacuity is also to be seen in the cranium of the golden eagle, but not in the white-headed species of North America. The anterior wall of the brain case in our subject is markedly concaved on its anterior aspect, and nonperforated beyond the usual foramina for vessels and nerves, all of which latter are comparatively small and individualized. So far as I have examined their crania, this is more or less true of all eagles.

As will be observed in Plate I, fig. 1, the quadratojugal bar in this monkey-eating eagle is quite straight, and of nearly uniform caliber from one end to the other. It is so in all true aquiline species, and in some the maxillojugal suture persists throughout the life of the individual.

A quadrate is a big, stout bone, with a well-developed orbital process, and a broad, smooth surface on its outer aspect. A broad, longitudinal valley lies between the two thoroughly separated articular facets that occur on its lower mandibular portion. It presents two heads for articulation with the skull, and they are separated by a wide, smooth notch. Nearly all parts of this cranium are pneumatic, and to this the quadrate forms no exception.

Either pterygoid bone is small, straight, short, and slender. When duly articulated, it does not come in contact with its fellow of the opposite side. In the golden eagle the outer margin of a pterygoid is very sharp and thin. This aspect in the white-headed eagle is longitudinally grooved, and the posterior extremity of the bone possesses an upturned process for additional articulation with the quadrate.

All true eagles possess a vomer, which is a long, thin plate

of bone compressed from side to side, with a finely pointed, free anterior apex; and, further, it is ununited posteriorly with the palatines.

*Pitheeophaga* possesses large, spongy maxillopalatines that fill up a good part of the rhinal chamber, being carried far to the front above the prepalatines, where they appear to merge to a slight degree. They are separated for their entire length in *Aquila,* but extensively fuse in *Haliæetus leucocephalus,* where they form a nearly solid roof in the mouth in connection with prepalatines and maxillaries.

*Pithecophaga* has a very solid bony nasal septum, as has the white-headed eagle; while in the golden eagle a good-sized vacuity may occur at the posterior superior angle.

The hinder part of a palatine in any true eagle has the postero-external angle rounded off, the bone in this locality being rather broad, with its inner margin produced and turned down, and its outer one to some degree thickened. In this part of their extent the palatines are in contact with each other, clasping the vomer between them anteriorly and the sphenoidal rostrum above.

The basipterygoidal processes are entirely absent in the skulls of all the eagles at hand at this writing, save in the case of the golden eagles, where they are represented by small triangular prickles, flattened from above downward. A lip of bone usually underlaps the entrances to the carotid arteries.

*Pitheeophaga*—and other species of eagles depart but little from it—presents a triangular area for the basitemporal space of the cranium, with a marked depression just anterior to the hemispherical occipital condyle. The foramen magnum is large and nearly circular in outline. A superoccipital prominence is fairly well developed in all these eagles, including the Korean species.

Although the "occipital area" is well defined, the ridge that exists to mark its limitations is not much raised. This is also true of the "crotaphyte fossæ," which are extremely shallow, subcircular in outline, and widely separated posteriorly. At the side of the cranium the crotaphyte fossa extends over onto the external surface of the postfrontal apophysis.

The cranial capacity is only of moderate proportions, when taken in conection with the balance of that part of the skull; and this is especially true of the cranium of *Pitheeophaga.*

Laterally, the osseous aural apertures are much exposed; in life, however, the soft structures of the internal ear are more or

less protected by the conformation of the quadrate when that element, upon either side, is placed in articulation.

There are some twelve to fifteen sclerotal plates to the circlet in either eyeball; the smaller ones are situated anteriorly and the larger ones behind (Plate III, fig. 9). Each platelet is an irregular quadrilateral in outline, the whole arrangement being fitted to the requirements of the form of the external moiety of the globe, assisting very materially in protecting it from certain injuries, and maintaining the sphericity of the organ. Additional strength is afforded through the generous overlapping of the plates.

We find the characters presented on the part of the mandible among the eagles pretty much the same, and it is V-shaped in all of the species at hand. In the long-faced species the V is more elongate, and the angle formed by the rami more acute. The bone is more or less pneumatic, which is also true of the cranium as a whole. In *Pithecophaga* a side of the mandible has a length of 9.7 centimeters, and the symphysis 2.5 centimeters, the latter being concave transversely above and correspondingly convex on its ventral aspect. All the elements are very solidly fused together, with the superior and inferior borders rounded. There are no perforating vacuities anywhere, the entire bone being very strong and smooth. A low coracoid process is present on either side, and from either of them the superior border slopes rather abruptly downward to the articular enlargement of the same side (Plate I, fig. 1; Plate III, fig. 4). Posteriorly, an articular extremity is considerably compressed from above downward, being truncate posteriorly. Its mesial, inturned process is somewhat elongate and well developed, with the usual pneumatic foramina near its apex superiorly. These processes are directed upward and inward, the apex in either case being blunt. Each presents two surfaces ventrally, and these are smooth. One surface is continuous with that of the jaw, the other pertaining to the underside of the inturned process.

Superiorly either one of these articular ends is concaved centrally, and that surface does not come in contact with the quadrate of the same side in articulation. Upon either side of this concavity, however, internally and externally situated, there is to be noted a conspicuous articular facet for articulation with the corresponding ones on the quadrate of the same side.

In many publications, here and abroad, I have described the skeletons of various species of eagles, falcons, hawks, and their

near congeners, both fossil and existing forms, and it may be said that we meet with few marked differences in any of them with respect to the characters presented on the part of the hyoidean arches, or skeleton of the lingual apparatus (Plate III, fig. 10).

The anterior soft part of the glossohyal is long and narrow, being covered for its anterior two-thirds with the usual horny sheath. Posterior to this, the glossohyal is narrow and bifurcated, articulating, as usual, with the basihyal posteriorly. This part is likewise thinly overlain with a horny sheath. All this part is very feebly developed, extremely elongate, and narrow.

Triangular in outline, the basihyal supports posteriorly an elongate urohyal, which is of small and nearly uniform caliber; it is tipped off with a very small bit of cartilage behind. This urohyal is perpendicular to the transverse line of the base of the basihyal, and in the right angle upon either side of the former articulates the head of a hypobranchial. Each hypobranchial is long and curved upward for its entire length. Both the anterior and the distal ends are somewhat enlarged, the posterior enlargements being continued in cartilage for a few millimeters, when, upon either side, its place is taken by a ceratobranchial. Either one of these is about 1.5 centimeters long, slender, and to some extent curved in line with the upcurved hypobranchial of the same side. Each ceratobranchial terminates behind in a fine, needle-pointed, cartilaginous tip.

Our white-headed eagle (*Haliæetus leucocephalus*) possesses a hyoid very similar to this; but the angle made by the urohyal and the basihyal is an obtuse one instead of a right angle, as it is in *Pithecophoga*, and the cartilaginous part of the glossohyal is extremely short, while the broad, osseous part has the form of a capital letter H, with the sides converging toward each other from behind forward.

Eagles, in so far as I have examined them, possess a very simple form of larynx and trachea. The former presents the usual osseous elements, but they form no special articulations with each other, the contour of the structure being sustained in their membrane, with the aforesaid elements simply maintained in their several positions by it, and nowhere in contact with each other. All the tracheal rings—and they are very numerous—appear to be, to some extent, performed in cartilage (Plate III, figs. 6, 10). Each is of the usual ornithic type, the broader ones being above and below. There are upward of seventy of

them, the lower end of the tube not having more than half the caliber of the upper, where it makes a simple union with the larynx. Distally, the bronchial branches are small, and but half closed in, the mesial aspect of either being a thin, simple membrane stretched across. There is a single pessalus present.

### THE SKELETON OF THE TRUNK

*The vertebral column.*—All the skeletons of eagles that I have examined possess fourteen vertebræ in the cervical region of the spine, between the cranium and the first true dorsal vertebra. Each of the last two cervicals—the thirteen and the fourteenth —supports a free pair of ribs. On the thirteenth the pair is rudimentary, to the extent that the body of the bone on either side is lacking to some considerable degree, while the articulation is perfect for the head and angle. With respect to the pair of ribs on the fourteenth cervical vertebra, it has a length of some 5 centimeters, terminating in a pointed, free extremity well above the sternum. As this is the case with respect to these last two vertebræ in *Pithecophaga*, *Thrasaëtos harpyja*, *Aquila*, and our white-headed eagle, it is probably what we will find in the skeleton of any true aquiline species, irrespective of the part of the world it inhabits. As a matter of fact, the vertebral column of this monkey-eating eagle of the Philippines is, character for character, almost the counterpart of that series of bones in the harpy eagle, and departs but very little from what we find in other species.

In our present subject the atlas lacks both neural and hæmal spines, while the articular cup for the occipital condyle is notched above. Laterally, there may be a notch or a foramen for the passage of the vertebral artery upon either side. Its neural arch is rather broad, and the facet for the centrum of the axis is quadrilateral in outline, the width being twice that of the vertical height. At the middle point below, it is pierced longitudinally by a minute foramen; a broad notch being found at the same place in the atlas of the white-headed eagle. In this species, too, similar notches allow, in life, the passage of the vertebral arteries to the cranial cavity. Similar ones, though larger, are to be seen in the axis of *Pithecophaga*, in which vertebra are developed a stumpy hæmal and a neural spine, as well as a more or less insignificant odontoid process.

The neural canal throughout the cervical series of vertebræ is cylindrical in form and quite uniform in caliber. From the third to the twelfth vertebra, inclusive, the lateral foramina for

the vertebral arteries are, in all instances, entire—that is, with respect to their osseous walls; on the other hand, the carotid canal is an open passage for the arteries of that name in the fifth to the ninth cervical vertebra, inclusive (Plate III, figs. 3, 5, 7, and 8).

All of these cervical vertebræ are very large and strong—indeed, quite massive in character. When present, the neural spine is situated just within the posterior margin of the bone; it is directed backward and upward in the third vertebra; is vertical and peglike in the next following one, with broader and triangular base in the next three (fifth to seventh inclusive), wherein it moves forward to the middle of the neural arch, the angle being situated anteriorly, and either side being directed backward and outward.

In the third cervical the prezygapophyses and postzygapophyses are joined by a plate of bone, in which appears, on either side, a small elliptical foramen; this foramen in the next following vertebra becomes an extensive subelliptical notch, being reduced to a minute spine on either side in the fifth vertebra.

Returning to the matter of the neural spines, we find that the broad, triangular form they assume—described in a previous paragraph—persists in the eighth to the twelfth vertebra, inclusive. Here they are more massive and occupy an extreme posterior position on the several remaining vertebræ of this series. On the twelfth the spine begins to assume the form of the neural spine as we find it in the leading dorsals, while in the thirteenth and the fourteenth not only are the neural spines in agreement with those processes in the thoracic vertebræ, but they present almost all the other characters of that series. In the midcervical series, the pleurapophyses are short and stumpy.

The rather massive prezygapophysial processes in the fifth cervical face directly upward; in the sixth they look inward and backward, and they maintain this position to include the ninth. In the rest of the series they face inward again. The "carotid canal" is present and open in the fourth to the eighth cervical, inclusive, being most nearly closed in the last one named.

Coming to the dorsal vertebræ (Plate IV), we find them very closely interlocked in articulation, with long, spinelike metapophyses on the last four of the five which occur in this section of the spinal column. The hæmal spines are stumpy and short, being entirely absent on the last two dorsals. The neural canal is cylindrical in form; the facets for each pair of ribs are entire

and are situated well back from the anterior limitation of the centrum on any particular vertebra; that is to say, there are no demifacets (Plate VI).

There are no epipleural appendages on either the last pair of the cervical ribs or the last pair of the pelvic ones (Plate IV); and, while of no great size on the first pair of dorsal ribs and the leading pair of pelvic ribs, they are conspicuously long and massive on the ribs of all pairs constituting the midseries. Any of these, in articulation, overlaps the body of the next rib behind; and all of these processes, at least in adult life, are very extensively and firmly coössified to the rib to which in any case they belong. With respect to direction, they all point upward and backward.

In the harpy eagle the basic portion of any one of these epipleural appendages is notably extensive, and occupies, in the case of the second pair to include the fifth, a large part of the posterior border of the rib—fully a third at least. There is a smaller pair of these apophyses on the last pair of pelvic ribs (Plate V).

All the ribs in *Pithecophaga*, save the cervical ones, articulate with the sternum by means of costal, or sternal, ribs; and there are no floating ones on the last pair as there are in the case of the harpy eagle (fig. 17). In our subject these sternal ribs increase in due proportion, in size and length, as we proceed from the first to the last pair; they are more or less massive, in keeping with the rest of the skeleton of this ponderous bird, and the last two pairs exhibit more or less upward curvature (Plate IV).

Our white-headed eagle has the last pair of pelvic ribs more or less feebly developed. The thoracic pair, upon one side or the other, may be more or less aborted with respect to its length and not descend to meet the usually well-developed corresponding pair of sternal ribs in this bird.

*The pelvis and the caudal vertebræ.*—When we come to examine and compare the pelves of various species of eagles from different parts of the world, we are struck by the marked similarity of form and of characters among them. This applies with special significance to the pelvis as we find it in our present subject and in the harpy eagle. Here the different characters are of the most trivial description possible—so much so, indeed, that a detailed account of the pelvis of an adult *Pithecophaga jefferyi* would answer admirably for the same bone of the skeleton in the harpy. Upon comparing Plates IV and V of the present memoir, it would appear that the disposition of

the hinder part of the pubic style was very different in the two birds; but this is by no means the case, for in the harpy those elements are held in their normal position, as in life, by a ligament stretching between their distal ends; while in *Pithecophaga,* when this ligament has been cut, it allows the pubic styles to spring away from each other and hang down as shown on Plate IV. Moreover, the point of view from which I photographed those two trunk skeletons was not quite the same, and this causes the reproduction of the rest of the bone to present slight differences, which do not really exist.

Viewed from above, it is to be noted that the ilia project considerably beyond the sacral crest; and on the upper surface of their anterior border there is a raised emargination which is produced backward and finally runs out as a bounding line to the postacetabular area of the superior surface of the sacrum upon either side. As the ilia pass the "sacral crest," their margins thoroughly coössify with it and in the same plane anteriorly—that is, up to the point where these bones begin to diverge and are raised above the general surface on this dorsal aspect of the bone. At the angle where this divergence commences, the sacrum and the ilia are completely fused, and every semblance of posterior openings of the "ilioneural canals" is completely obliterated. So, too, with the rather abruptly downward-sloping "postacetabular area;" here, likewise, every semblance of sutural traces—the intersacroiliac ones—has been absorbed; while the intervertebral foramina, so conspicuous in this area in the pelves of some birds, are reduced to mere little pits in the general surface of the bone (Plate VI).

Seen upon lateral aspect (Plate IV), the anterior two-thirds of bone—or all that part anterior to and above the acetabulum and antitrochanter—is supplied by the ilium of that side. Its surface is generally concaved and faces upward and outward. Anteriorly, its outer border is emarginated, and below this may be seen the forepart of the pelvic sacrum, the continuation of which, posteriorly, may also be observed through the large, circular acetabulum and immense ischiadic foramen; the former is entirely lacking in any osseous base, while the latter occupies fully one-half of the lateral area posterior to the rather large, subtriangular antitrochanter and elliptical obturator foramen. Posterior to this great ischiadic foramen, the lateral surface of the ischium is triangular in outline, concave above, convex below, and smooth throughout. The rounded posterior ischiac border is nearly straight and presents no semblance of any indent that might suggest the presence of an "ilioischiadic."

The pubic style closes the obturator foramen; and, after passing it along the lower margin of the ischium, it becomes much attenuated and terminates as a fine point in a line below the middle of the ischiadic foramen above it. A small interval is then present, when the bone begins again in a fine point, to increase gradually in size as it passes below the inferior ischiac border, to be produced posteriorly in a much thickened condition in the direction of its fellow of the opposite side.

Ventrally, the pelvis of this eagle presents many interesting features. As well as I am able to judge from the pelvis of an adult bird of this species, the sacrum would seem to contain fifteen vertebræ, or the same number as we find within the grasp of the iliac bones of the harpy's pelvis. The leading seven possess very large centra, and they have their lateral processes extending upward and outward, to coössify with the ventral surfaces of the ilia. Posterior to this arrangement, we arrive at the very deep pelvic basin, where the three vertebræ opposite the cotyloid rings fail to throw out lateral processes. These are followed by three others that have the lateral processes for their external moieties fused into a common plate of bone upon either side, which fuses outwardly with the inner surface of the pelvic wall. A row of three elliptical foramina is left upon either side of the centra here, and osseous trabeculæ are thrown up into the deep space above. Finally, the two terminal sacral vertebræ occupy a much lower plane than the preceding—that is, their transverse processes do—and these are thrown directly outward, to fuse distally with the inner wall of the ischium upon either side. Below them the surface—and it is an extensive one—on either hand is smooth, being furnished entirely by an ischium.

The conformation I have attempted to describe here gives rise to four fairly well-defined cavities, each imperfectly walled in by the surrounding parts of the pelvis as a whole. Through these cavities, mesially, passes the big, coösified pelvic "sacrum." The first cavity occupies the anterior half of the pelvis backward to a point where the vertebræ cease to send their lateral processes directly outward to the iliac walls upon either hand. Then follows the well-marked, deep cavity opposite the acetabulæ; posterior to this we define cavity number three, which lies between the big ischiadic foramina; and, finally, ventrad to the last two, there is the general concavity of the pelvic basin, having cavities two and three above it, and its lateral walls formed by the ischium, descending deeply upon either side.

The skeleton of the tail of this eagle is composed of eight free vertebræ, plus a large, quadrilateral pygostyle. The first three vertebræ are pneumatic, while the rest of this caudal series does not enjoy this condition. Passing to the harpy eagle, we find that the tail skeleton contains but seven free vertebræ and a pygostyle; the latter is similar to that of the monkey-eating species, but here the leading four vertebræ are pneumatic—the rest are nonpneumatic (Plate III, fig. 1, and Plate V). These vertebræ, including the pygostyle, are massive in structure, and present the usual ornithic characters of this part of the vertebral skeleton in the aquiline types.

*Pithecophaga* possesses a very large quadrilateral pygostyle, the lower portion of which seems to be a coössified terminal caudal vertebra, though now an inherent part of the bone and included in giving to it its peculiar shape. Superiorly and anteriorly the pygostyle possesses sharp edges, while the posterior one is thickened and rounded. Above its articulation in front, there is a small opening for the terminal of the spinal cord to enter, and below this, a double-faced articulation for the last free caudal vertebra. Just posterior to this the pygostyle is perforated from side to side by a smooth, subcircular foramen of some size (Plate III, fig. 2). The lower half, posteriorly, has the form of an isosceles triangle, with the apex above. Its sides are rounded, and its base is much thickened. Interiorly it is excavated, and the above-described foramen passes through the excavation, while the floor of the excavation exhibits a larger foraminal opening of an elliptical outline, with the major axis in the anteroposterior line.

In the harpy eagle a stumpy apophysis projects from the superoposterior angle of the pygostyle, while the foraminal openings are generally smaller. Throughout the falconine types of the world the pygostyle, while it may vary somewhat in form, possesses the same general characters, is always conspicuously large, and is commonly of a quadrilateral form.

*Bones of the shoulder girdle, or pectoral arch.*—Taking into consideration the marvelous power of flight possessed by this big eagle, we need experience no surprise at finding the bones composing this distinctive arch as in all birds of great strength, massive in structure (Plate IV). This is preëminently true, and probably no existing bird of its size possesses bigger and stronger bones in its shoulder girdle than an average eagle; to this statement our aquiline giant of the Philippines forms no exception. As is the case with all the bones of the trunk skeleton,

they are highly pneumatic in character, and consequently very light in weight for their size.

The os furculum, or fourchette, has the form of a very wide-spreading capital U; the lower part of the arch is not especially strong, while it rapidly increases in size from below upward, to terminate in immense, free clavicular extremities. Either of these is much compressed from side to side, with its great superior end accurately molded, externally, to the mesial head of the scapula of the same side. When duly articulated, its apex barely comes in contact with the anteromesial angle of the head of the scapula of the same side.

The clavicular limbs of the furculum are greatly compressed from side to side, and the edges thus formed are sharp, especially the mesial ones. There is but small evidence of a hypocleidium, and the entire bone is powerfully curved backward and upward. Its pneumatic foramina are principally situated in the concavities of the upper clavicular extremities, upon their moderately shallow outer concavities, on that part of the bone, upon either side, which goes to complete the foraminal passage among the heads of the three bones of this girdle.

The os furculum in the skeleton of our subject agrees very well with the corresponding bone in the harpy eagle; though in the latter species the free clavicular ends are more extensively rounded off than they are in the case of the Philippine bird. Our white-headed eagle possesses a more delicately fashioned furculum, while in such a form as *Thallasoaëtus pelagicus*, of Korea, the clavicular free ends are enormously developed; but, owing to the high degree of pneumaticity, the bone, as a whole, is extremely light in weight. Doubtless other eagles present still other differences, not only in the furculum, but also in the remaining bones of the girdle.

When articulated as in life, the coracoids in *Pithecophaga* do not meet in the median line, being separated by an interval of several millimeters. Either bone is very massive in form; but is light in weight, owing to the high degree of pneumaticity it enjoys. All of its parts are conspicuously developed, the broad scapular process being perforated by a foramen piercing it from before backward. There may be pneumatic foramina of some size on the mesial aspect of the big head of the bone and still others on its outer aspect. A sternal extremity is considerably expanded, the bone in articulation extending beyond the sternum laterally. Here it is much compressed from before backward, and thickened at its mesial angle.

The harpy eagle possesses coracoids very similar to those of *Pithecophaga*, while in the American white-headed species the head of the coracoid is much compressed from side to side.

In agreement with the other bones of its pectoral arch, *Pithecophaga* possesses a scapula of great size and unusual strength. As in the case of the coracoid and the furculum, it is highly pneumatic, the foramina for the admission of air into its interior being found on the ventral aspect close to the head of the bone. The head is broad from side to side and somewhat compressed from above downward: at its outer angle there is an elliptical articular surface that constitutes about one-third of the glenoid cavity, while at the mesial angle a big quadrilateral process projects forward for the attachment of the coracoscapular ligament. The neck of the bone is broad and thick; the borders are rounded off. This part constitutes about one-third of the blade; posterior to it we have the curved scimitarlike blade of the bone. This is carried backward to a blunt point, the outer border being rounded, and the mesial one having a thickened edge; the latter commences abruptly near the middle point of the bone as a whole. From head to apex this scapula presents a uniform and gentle curvature in the plane of the bone's blade, the concavity of the curve being along the outer border.

The harpy eagle has the distal moiety of a scapula very broad, with the outer margin sharp, but the inner one rimmed pretty much as we find it in the monkey-eating species. In the golden eagle the terminal part of the blade is distinctly truncated, and the entire bone is much compressed from above downward. This is also true of the scapula in our white-headed bird; here the blade is extremely narrow and is drawn out posteriorly to a truncated apex. In this species it does not seem to be especially pneumatic. The Korean eagle has a scapula resembling that bone in the golden eagle.

These birds—*Pithecophaga* forms no exception to the rule—possess a big sternum of extraordinary capacity. Ventrally it is one deep basin from side to side as well as lengthwise. Down the middle line there is a row of scattered foraminal openings to admit air during the life of the individual. Its xiphoidal border is at right angles to the long axis of the bone and presents but a shallow concavity for its middle third. Well within this border, upon either hand, there is an elliptical foramen of no great size. Seven facets occur upon each costal border, with a great many pneumatic foraminal openings among them. Their interarticular cavities are very shallow. On the outer aspect of

the body of this sternum, at the anterosuperior angle and including the distance occupied by the first four hæmapophysial articular facets, there is a marked concavity which is the continuation of the costal groove of the same side. Its lower boundary is curved, with the convexity toward the keel (Plate IV). The keel is not deep by any means and is continued only two-thirds the length of the body, its lower border being uniformly convex. Anteriorly, the carinal angle is rounded off, the concave, anterior border above it being sharp for its lower half and flat for its upper, terminating superiorly in a stumpy manubrium, which is truncated anteriorly, leaving, as it were, a small, triangular surface, with the angle below in the middle line. The deep coracoidal grooves are remarkably well defined in front, in the middle line, at which point they decussate to some extent.

The external surface of the sternal body, upon either side of the carina, is smooth, and the line of the pectoral muscle is but faintly defined. Occasionally we find in the body of the sternum of this and other eagles one or two small, sporadic foraminal openings, just as though a bird shot had made a perforation and the wound subsequently healed. I find a rather large, nearly circular one of these in the sternum of the harpy eagle, it being situated on the right side of the body of the bone, near its middle. In this species the sternum is somewhat smaller than the one just described; but, ventrally, it presents the same profound concavity, with fewer evidences of pneumaticity, however. The xiphoidal elliptical foramina, one upon either side, are very much larger; and this extremity of the bone has an increased width due to the lateral extension of the xiphoidal portion, which is well seen upon lateral view (Plate V). There is the same number of articular facets upon either costal border as we described for *Pithecophaga jefferyi*—indeed, all eagles seem to have the same number. The Korean eagle lacks any foraminal openings in the xiphoidal end of the bone, and the sharp border there is entirely lacking in notches, being wholly at right angles to the carina, which fails to run out to it by at least 2 centimeters. Within the thoracic cavity of the body of the bone foraminal perforations occur not only down the middle line of the bone to a point opposite the last pair of facets on the costal borders, but likewise in a great area in front and along both sides to a similar point. The coracoidal grooves decussate in this eagle, as they do in the white-headed species, and they are invariably of some considerable depth. In the latter bird there is also an absence

of the xiphoidal foramina, and that border presents a squarish prolongation of no great size in the middle line; it possesses all the other aquiline characters of this bone.

In the bearded vulture, of Europe, the body of the sternum is square in outline, and not a parallelogram as in eagles; its coracoidal grooves do not decussate, and it has but six pairs of costal ribs. In fact, the bone is that of a big vulture, and in no way suggests that of an aquiline species of any sort.

*The pectoral limb.*—Plates VII and VIII. It has long been a well-known fact that all big raptorial birds possess limbs of great size, power, and proportions. This is what we would usually look for when we come to consider their habits and the character of their prey. It also explains the fact that most of the bones of their limbs enjoy a very perfect state of pneumaticity; the skeleton of the foot, however, often forms an exception to this condition. Possibly, in some of our eagles, even the foot bones may be pneumatic; they appear to be so in some degree in our white-headed species, but surely not in the golden eagle. True vultures, almost without exception, possess a skeleton presenting a lightness and an extremely perfect pneumaticity unequaled by any other family of birds. *Gypaëtus* forms a partial exception to this rule, in so far as the skeleton of its feet is concerned; but this bearded species approaches the eagles, while our American vultures are birds that practice long-sustained and steady flight, and do not capture their prey—hence a more perfect aëration has evolved in them.

In the different species of eagles, in so far as I have examined them, the humerus varies but little in form or in general characters. It is invariably a large and thoroughly pneumatic bone, and to this statement *Pithecophaga* presents no exception. It has a length of about 20 centimeters; and, taken as a whole, its shaft presents the "sigmoid curve" in a nearly perfect degree. Rather less than its middle third is very smooth and quite cylindrical in form. Its radial crest is short and triangular in outline, while the ulnar tuberosity is very conspicuously developed and arches over—to some considerable extent proximally—the deep pneumatic fossa, in which may be seen the pneumatic foramina of very large size, but generally few in number. There is also a row of these foramina along the base of the smooth, elliptical head of the bone on the anconal side; they are of no great size in this locality. A very distinct elongate elliptical area—raised above the general surface—with its major axis parallel to the bone's shaft, may be seen at the distal

base of the radial crest on the palmar aspect of the expanded proximal end of this humerus; it denotes the place of insertion, in life, of the pectoralis muscle, and is found in the same location in all true eagles.

All of the ornithic characters seen in the avian humerus, in so far as falconine species go, are to be found at the distal end of this bone of our present subject, and each and all of them are unusually prominent. This applies especially to the two articular tubercles, the trachial fossa, and the tendinal grooves on the anconal aspect. In the aforesaid fossa a few, small, scattered, pneumatic foramina may be observed, especially just beyond the radial and ulnar tubercles.

The radial crest of the left humerus of this individual exhibits the results of some previous disease, and it has manifested itself in the form of quite an extensive exostosis. The ulnar crest is carried down onto the shaft for a distance of about a centimeter as a sharp and distinct border; while at its middle we note a small foraminal perforation, with a groove leading into or out of it, on the palmar surface of the proximal, expanded extremity of this bone.

This foraminal perforation is absent in the radial crest of the humerus of the harpy eagle, and the crest itself is of a triangular outline (Plate VII, fig. 2); while otherwise, in all other matters, the two bones are notably similar in these two eagles. However, in the harpy it may be noted that the caliber of the shaft is greater and presents less sigmoidal curvature.

In the Korean eagle (*Thallasoaëtus pelagicus*) the humerus is fully 1.5 centimeters longer than it is in *Pithecophaga jefferyi*; it is also straighter and somewhat slenderer. Its large, triangular, radial crest extends farther down the shaft, while in all other respects the two bones are very similar. Curiously enough —the above fact notwithstanding—the skull of the Korean bird is neither as large nor as massive as is the skull of the eagle of the Philippines. This difference is possibly due to a longer wing in the former species; but the material is not at hand at this writing either to prove or to refute any such statement.

In September, 1918, I published an account of *Pithecophaga jefferyi*, illustrated by natural-sized figures of its head and foot.[1] In that article I made the statement that the species was the largest of all existing raptorial birds. Possibly this may be so; while, upon the other hand, the big eagle of the Orient (*Thalla-*

[1] Am. Forestry 24 (1918) 555–557, 2 figs.

*soaëtus pelagicus*), found in Kamchatka and Japan as well as in Korea, may be a bigger bird in some respects. Sharpe included the Old World vultures in the true raptorial group. In the genera *Vultur* and *Serpentarius* there are some big species the comparative weights and proportions of which have never been taken for a series of living specimens or compared with the corresponding data on *Pithecophaga jefferyi.*

I have never compared the wedge-tailed eagle, *Uroaëtus audax* Lath., of Australia and Tasmania, with our present subject; but I am inclined to believe that it is not so large a bird.

The radial crest of the humerus of the white-headed eagle of the United States is also triangular in outline; while in *Aquila chrysaëtos canadensis* this feature of the bone under consideration is not so lofty and, while triangular in general outline, it extends very much farther down the shaft of the bone. Here, too, the osseous emargination of the pneumatic fossa is broader and more extensive, thus closing in upon the true cavity, though in no other way diminishing its capacity.

The bearded vulture of Europe has a humerus fully one-third larger than that bone in *Pithecophaga,* and its characters are very similar, the most striking departure being the shallow pneumatic fossa in the former species, with all of its foramina merged into one subcircular foramen.

In the antibrachium of *Pithecophaga* both the ulna and the radius exhibit some degree of curvature between proximal and distal extremities. Air gains access to their interiors through minute foramina at the proximal and the distal end of each; at the latter situation they articulate in the usual manner with the radiale and the ulnare of the carpus, bones that here present the avian characters usually seen among the eagles. The radius has an extreme length of some 20.5 centimeters, and the ulna is about 2 centimeters longer than this. The latter bone has a double row of osseous papillæ down its cylindrical shaft; these, as in other birds, are for the attachment of the quill butts of the secondary feathers of the wing. There are ten in each row, and all, to the last pair at either end, are opposite each other. The anterior third of the radius is subcylindrical in form, while the remainder of the shaft is trihedral on section. Its "radial tuberosity" is concaved in the center, with the inner margin sharp. Our harpy eagle skeleton lacks the bones of the forearm and manus.

*Thallasoaëtus pelagicus* has the radius and the ulna much longer than the monkey-eating eagle, and each is markedly

slenderer. We are also to notice that the papillæ on the shaft of the latter are closer together. Ten pairs of them appear to be present, and the ulna in this bird has an extreme length of 24.3 centimeters.

America's golden eagle departs from others examined, in that the humerus and the femur are the only pneumatic bones of the pelvic and pectoral limbs.

Unfortunately, I have not at hand the skeleton of manus either in the case of the harpy or of the species here being osteologically considered; so that a description of these parts will have to be undertaken by someone else, when such material falls into the hands of science. Very likely, in other published papers of mine, descriptions of these parts of the skeleton in other species of eagles will be found, either of fossil or existing species.

*The pelvic limb.*—Plate VII, fig. 1; and Plates IX, X, and XI. *Pithecophaga jefferyi* possesses a big femur, which is permeated by air in all of its parts. There is an extensive group of pneumatic foramina in the deep popliteal concavity, and another large opening on the proximal end of the bone anteriorly, at the termination of the trochanter major; it is bounded internally by the linea aspera. Caput femoris is sessile, with an extensive pit for the ligamentum teres. The summit is smooth and convex from before backward, and concave from head to the trochanter, which latter rises above the summit of the bone. It is very broad and rough on its external surface. Passing to the shaft, we find that to be very stout and uniformly arched, the convexity being in front. For its middle third it is subcylindrical in form and very slightly roughened throughout.

Distally the condyles of this femur are enormous with very prominent articular surfaces. The side of the inner condyle is, for the most part, flat and smooth, while the outer one is slightly roughened and presents a conspicuous tuberosity. As usual, this condyle is vertically divided posteriorly, in that it may articulate with the head of the fibula of the leg. This femur has an extreme length of about 13.2 centimeters, or 2 millimeters more than the length of the femur of a harpy eagle; but the little that the harpy lacks in length in this bone it amply makes up in stoutness; and, apart from this general stoutness, there is no specific difference worthy of notice or description.

The femur of the golden eagle is of about the same length as the two just noticed; but it is a far slenderer bone, with the elliptical pneumatic foramen at its proximal end very conspicuous, and the muscular lines on the shaft are likewise so. The poplit-

cal cavity is shallow in the femur in this species, as it is in some other eagles. *Haliaëtus leucocephalus* also has a slenderer femur, while *Thallasoaëtus pelagicus* has one of moderate proportions—that is, not as long or as stout as in *Pithecophaga*, and the shaft is slightly more curved. In the femur of this species the noteworthy characters consist in the great prominence of the tubercle on the outer condyle and the unusual depth of the pit on the caput femoris for the ligamentum teres.

Air does not enter so extensively into the bones of the leg in *Pithecophaga* as it does in the case of the femur. Still, they are to some considerable degree pneumatic; for, upon ordinary maceration, the bones largely whiten, though not nearly as much as does the femur, while in no part do they turn fatty yellow, as happens to the metatarsus and toe bones after similar treatment.

The tibiotarsus in *Pithecophaga* measures some 20.4 centimeters in length, and the fibula measures 15.8 centimeters (compare Plate VII, fig. 1, and Plate IX, figs. 2 and 3). The first-named bone is nearly straight from end to end, being but very slightly arched to the front. For its distal third it is markedly flattened in the anteroposterior direction—less so above, where it is flat for its anterior surface and sides, the shaft being here trihedral on section. Distally the condyles are very much suppressed posteriorly and correspondingly pronounced in front, where the valley between them is deep. Above them, to the inner sides, the tendinal groove is of great depth; it is very distinctly defined as to its boundaries, and the oblique "tendinal bridge" is strong and similarly characterized.

Proximally the raised ridge for articulation with the fibula has a length of 3.5 centimeters and lies wholly within the upper third of the shaft, which here is very flat and smooth. Above this we note the low and short cnemial processes, separated by a wide and rather deep valley. The ectocnemial process terminates in a rather blunt, down-turned hook, extending but very slightly above the summit of the bone. The latter slopes to the outer side, and presents a prominent, rounded, articular tubercle near the head of the femur, which may or may not be especially noticeable in this bone in other eagles. At the sides, as well as posteriorly, the summit bulges out over the shaft, being most thickened along its inner course, beyond which point a concavity occurs, bounded in front by the entocnemial process.

Turning to the fibula, it is to be observed that its shaft below the fibular ridge of the tibiotarsus is long and slender, being much compressed anteroposteriorly, opposite the middle third

of the companion bone of the leg. Below this, it runs onto the shaft, and here the contact almost amounts to a direct fusion with it. At its lowest point it is not over 3.5 centimeters above the lower margin of the external tibial condyle. All diurnal Raptores possess fibulæ of greater or less length; especially do we find this to be the case in *Pandion*. Superiorly, in our subject, the fibula is much compressed from side to side, with its head produced posteriorly. Its entire summit, convex from before backward, is an articular facet for the outer condyle of the femur.

*Pithecophaga* possesses a rather large patella, which is elongate from side to side, in which direction the surface is convex, while posteriorly it is concave above and doubly concave posteriorly for articulation with the condyles of the femur. Inferiorly, the surface is limited and flat. Sometimes, as in the case of our present subject, there is a small, circular ossification in the tendon of the muscle, several millimeters below the true sesamoid of the knee joint; it occurs in both limbs.

Eagles exhibit very considerable variation in their leg bones, but more in the tibiotarsus than in the fibula. For instance, in the harpy the latter bone is more than a centimeter shorter than it is in the Philippine bird now being described, while at the same time the shaft is very conspicuously flattened from before backward; at the same time, this flattening is associated with a marked increase in the shaft's width. With respect to the fibula of the harpy, it broadens below the articular ridge, and is grooved for the passage of the muscle that passes over it (Plate VII, fig. 1). In the white-headed eagle the cnemial processes of the tibiotarsus are greatly reduced in all particulars, and to a lesser extent this is also true of the Korean eagle: the fibula is very long in the species.

With respect to the golden eagle (*Aquila chrysaëtos canadensis*), the bones of the leg are nonpneumatic for their entire length below the proximal extremities, the shaft of the tibiotarsus in this species being curved from end to end, the concavity being along the inner or mesial aspect.

*Skeleton of the foot.*—Plates X and XI. As already noted, the tarsometatarsus and other bones of the foot in this eagle are entirely nonpneumatic, while in some other forms the reverse of this is the case (*Haliæctus leucocephalus*). Irrespective of species the tarsometatarsus possesses the same general characters throughout the group, and its form is very characteristic. All this part of the skeleton in the harpy was left in the skin of

the mounted specimen at the United States National Museum, so that no comparison can be made here along such lines with the corresponding bones in our subject. In the latter the bone has a length of about 12 centimeters and an average breadth of 2 centimeters. Its summit exhibits two shallow articular facets for the condyles of the tibiotarsus. An intercondylar tubercle stands between them on the anterior margin, the width of the surface being double its depth, while posteriorly is to be noted a hypotarsus of the usual aquiline type. This consists of a quadrilateral process standing out at right angles to the bone—its hinder border being considerably thickened—and its base opposite the inner articular concavity at the summit. Opposite the outer one is another process, it being stumpy and much aborted; between the two is a wide, shallow valley.

Posteriorly the shaft of this tarsometatarsus is smooth, broad above, and somewhat narrower distally. It is concaved throughout its entire extent, its margins being more or less sharpened, except where the accessory metatarsal is swung by ligament about a centimeter above the inner trochlea. The outer aspect of the shaft is flat, being broad at the middle third, and tapering somewhat to the ends. It is the posterior margin of this surface that forms the inner sharpened border of the posterior aspect alluded to above. Anteriorly the surface is much twisted upon itself, the upper half being concaved longitudinally and convexed for the rest of the extent, the two merging into each other. At the upper third, anteriorly, we note the usual twin perforations a short distance below the summit; and below them, to the outer side, is the elongate tubercle for muscular insertion.

Distally there are three very substantial trochleæ for the basal phalanges of the toes, the inner one being the largest and at the same time the lowest on the shaft. Slightly up on the shaft, between the outer and middle condyle, is to be noted the usual foraminal perforation present in nearly all birds; it transmits the flexor tendon of the outer toe and, it is said, the anterior tibial artery.

The accessory metatarsal is of considerable size, is flattened and somewhat twisted upon itself, and supports distally a very large, transversely disposed, trochlear facet; the latter is devoted to the articulation of the basal joint of the hallux, which is a digit of enormous power and strength, as will be appreciated through a glance at Plate X. Equally powerful are the joints and the talons of the anterior toes, the arrangement and pro-

portions of which are upon the usual ornithic plan of the aquiline pes, with the osteological characters I have often described before, of existing forms as well as of fossil eagles.

## CONCLUSIONS

Coming to the relationships of *Pithecophaga jefferyi*, with respect to other representatives of the same group and in the light of the osteological material above described and compared with its skeleton, I am of the opinion that its nearest ally, in so far as we are at present acquainted with the morphology of other eagles, is the harpy eagle (*Thrasaëtos harpyja*).

Sharpe[2] makes a very different disposition of this species; he places it between *Circaëtus* and *Spilornis*, of the Aquilinæ (Subfamily V); while the harpy eagle we find arrayed with the Buteoninæ (Subfamily III), following *Harpyopsis*, the next following Subfamily (IV) being the Gypaëtinæ (*Gypaëtus barbatus*). The osteology of *Pithecophaga* surely does not support this arrangement.

## PREVIOUS PAPERS BY THE AUTHOR ON THE OSTEOLOGY OF THE EAGLES AND THEIR ALLIES

[Papers on the owls and the vultures are not included.]


1. On the ossicle of the antibrachium as found in some of the North American Falconidæ. *Bull. Nutt. Orn. Club* 6 (1881) 197–203.
2. On the free post-pubis in certain of the Falconidæ. *Auk* 3 (1886) 133, 134. 1 text figure.
3. Osteology of Circus hudsonius. *Journ. Comp. Med. and Surg.* 10 (1889) 126–159. 17 text figures.
4. A peculiar character referable to the base of the skull in Pandion. *Auk* 8 (1891) 236, 237.
5. Some comparative osteological notes on the American kites. *Ibis* VI 3 (1891) 228–232.
6. On a collection of fossil birds from the Equus beds of Oregon. *Am. Nat.* 25 (1896) 303–306. Plates.
7. Fossil birds from the Equus beds of Oregon. *Am. Nat.* 25 (1891) 818–821.
8. Tertiary fossils of North American birds. *Auk* 8 (1891) 365–368.
9. A study of the fossil avifauna of the Equus beds of the Oregon Desert. *Journ. Acad. Nat. Sci. Philadelphia* 9 (1892) 389–425, pls. 15–17.
10. On cases of complete fibulæ in existing birds. *Ibis* VI 6 (1894) 361–366, figs. 1, 2.
11. Some of the "outliers" among birds. *Pop. Sci. Monthly* 44 (1895) 760–780. 10 text figures (not osteological).
12. On the affinities of Harpagornis. *Trans. New Zealand Inst.* 28: 665.
13. Observations on the classification of birds. *Proc. Acad. Nat. Sci. Philadelphia* (1898) 489–499. Illustrated. (Osteology largely used.)


[2] A Hand-list of the Genera and Species of Birds. London 1 (1899) 265.

14. An arrangement of the families and higher groups of birds. *Am. Nat.* 38 (1904) 833-856, text figs. 1-6. (Osteology largely used.)
15. Where the skeletons of American birds may be studied. *Auk* 26 (1909) 217–218.
16. Osteology of birds. *Bull. N. Y. State Mus.* 130 (1909) 367 pp. Education Department Bulletin No. 447. (This book contains many cuts and plates devoted to the osteology of the Falconidæ and has been particularly useful in studying the skeleton of the eagles.)
17. Review of the fossil fauna of the desert region of Oregon, with a description of additional material collected there. *Bull. Am. Mus. Nat. Hist.* 32 (1913) 123–178, pls. 9–13, figs. 1–578.
18. Further studies of fossil birds, with descriptions of new and extinct species. *Bull. Am. Mus. Nat. Hist.* 32 (1913) 285-306, pls. 51-59, figs. 1-94.

# ILLUSTRATIONS

[All the figures are reproductions of photographs by the author made direct from the specimens.]

## Plate I

Fig. 1. *Pithecophaga jefferyi*, adult; right lateral view of the skull, natural size. All the bones of this bird figured on the plates are of two individuals. The specimens were received from Mr. R. C. McGregor, of the Bureau of Science, Manila, P. I.

2. The skull shown in fig. 1, seen directly from above, natural size.

## Plate II

Fig. 1. *Haliæetus leucocephalus*, white-headed eagle, sex?, adult; cranium, direct view from above, very slightly reduced. Median longitudinal diameter measures 11.1 centimeters in this specimen. No. 19278, United States National Museum collection. This skull belongs to the skeleton of the specimen used throughout this paper.

2. *Aquila chrysaëtos*, female, adult; cranium, direct view from above, very slightly reduced. Median longitudinal diameter measures 11.9 centimeters in this specimen. No. 18802, United States National Museum collection.

3. *Morphnus guianensis*, sex?, adult; cranium, direct view from above, very slightly reduced. Median longitudinal diameter measures 9 centimeters in this specimen. No. 18468, United States National Museum collection.

## Plate III

[All figures of Plate III natural size and from the same species, *Pithecophaga jefferyi*.]

Fig. 1. The six caudal vertebræ (*a* to *b*) arranged in normal sequence and viewed from above; *a*, anterior one of chain.

2. Pygostyle, right lateral aspect. Lower part pierced by a foramen.
3. Fifth cervical vertebra, seen from above.
4. Mandible, seen from above.
5. Anterior aspect of ninth cervical vertebra.
6. Trachea, twisted and distorted through drying; fragments of bronchial tubes at inner end.
7. The atlas, posterior aspect.
8. Anterior view of axis; neural spine directed downward.
9. Sclerotal circlets of the eyes; elements as they occur or are arranged in life.
10. Hyoid arches viewed from above, with larynx in situ; the latter removed at a point seen at the outer end of the trachea in fig. 6.

## Plate IV

*Pithecophaga jefferyi*; right lateral view of the trunk skeleton, including bones of the shoulder girdle, reduced about one-third. The pygostyle and the six caudal vertebræ preceding it have been removed.

PLATE V

*Thrasaëtos harpyja*, harpy eagle; right lateral view of the trunk skeleton, including bones of the shoulder girdle, reduced less than one-half. Length of sternum in the specimen equals 13 centimeters. No. 225806, United States National Museum collection; a specimen from Brazil.

PLATE VI

*Pithecophaga jefferyi;* trunk skeleton, seen upon direct dorsal view, with the shoulder girdle in situ, reduced about one-third. The pygostyle and the six caudal vertebræ preceding it have been removed.

PLATE VII

FIG. 1. *Thrasaëtos harpyja;* anterior aspect of the right tibiotarsus and fibula, slightly reduced. From the same specimen as Plate V.

2. *Thrasaëtos harpyja;* anconal aspect of left humerus, slightly reduced. From the same specimen as Plate V.

PLATE VIII

FIG. 1. *Aquila chrysaëtos*, golden eagle; anconal aspect of right humerus. No. 18802, United States National Museum collection. Length of bone, about 18.2 centimeters.

2. *Thrasaëtos harpyja;* anconal aspect of right humerus. From the same specimen as Plate V.

3. *Pithecophaga jefferyi;* anconal aspect of right humerus, reduced about one-third. Bone in life measures about 19.7 centimeters in length.

PLATE IX

FIG. 1. *Pithecophaga jefferyi;* left femur, posterior aspect. Extreme length of bone in specimen, about 13 centimeters. Bone entirely pneumatic.

2. *Pithecophaga jefferyi;* right tarsometatarsus and fibula, viewed on direct anterior aspect. Length of tarsometatarsus in specimen, about 23 centimeters.

3. *Pithecophaga jefferyi;* left tarsometatarsus and fibula, viewed on direct outer aspect.

PLATE X

*Pithecophaga jefferyi;* skeleton of the right foot, mesial aspect, natural size.

PLATE XI

FIG. 1. *Haliæetus leucocephalus;* skeleton of right foot, inner aspect, natural size. No. 19278, United States National Museum collection.

2. *Haliæetus leucocephalus;* skeleton of left foot, outer aspect, natural size. The same bird as in fig. 1.


PLATE I. PITHECOPHAGA JEFFERYI.

PLATE II. CRANIA OF THREE EAGLES.

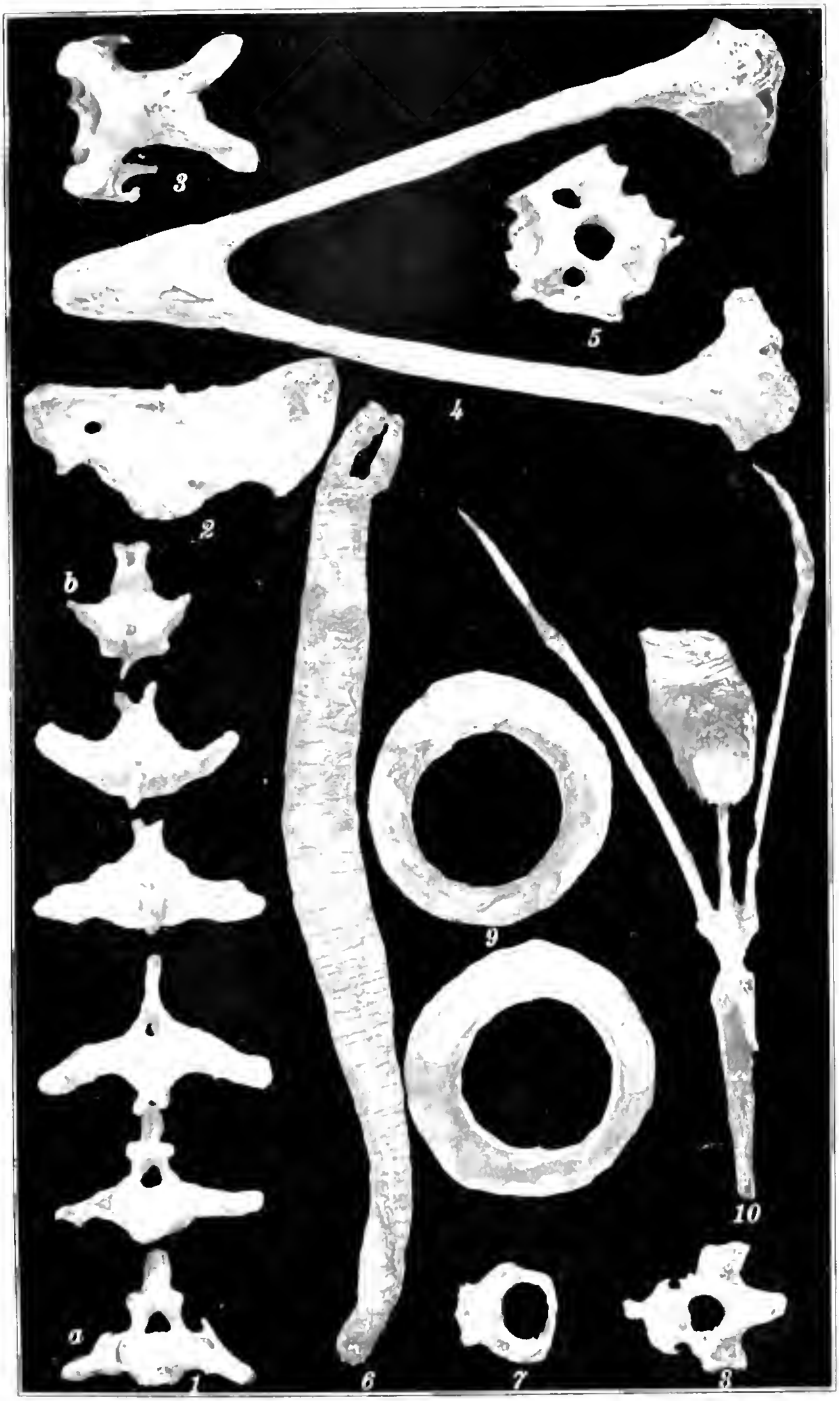



PLATE III. PITHECOPHAGA JEFFERYI.

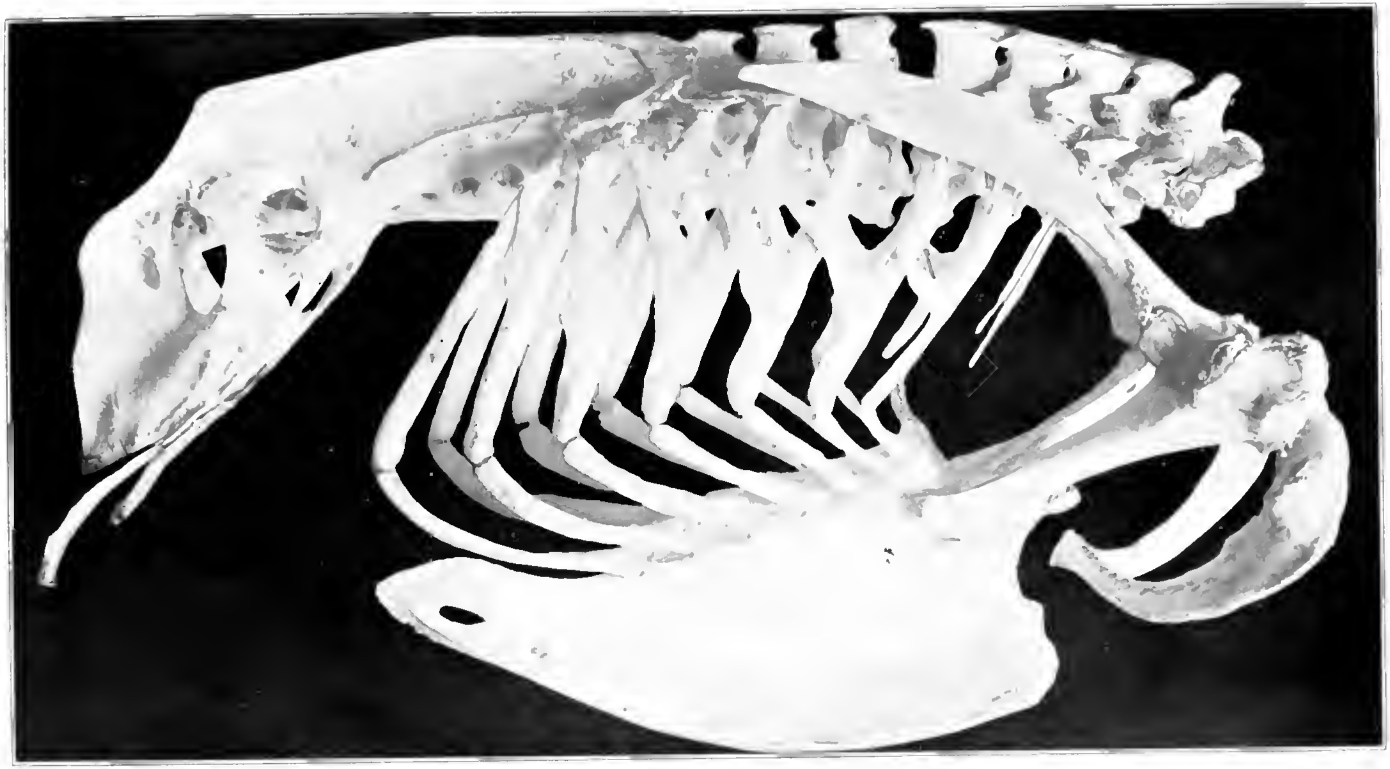


PLATE IV. TRUNK SKELETON OF PITHECOPHAGA JEFFERYI.

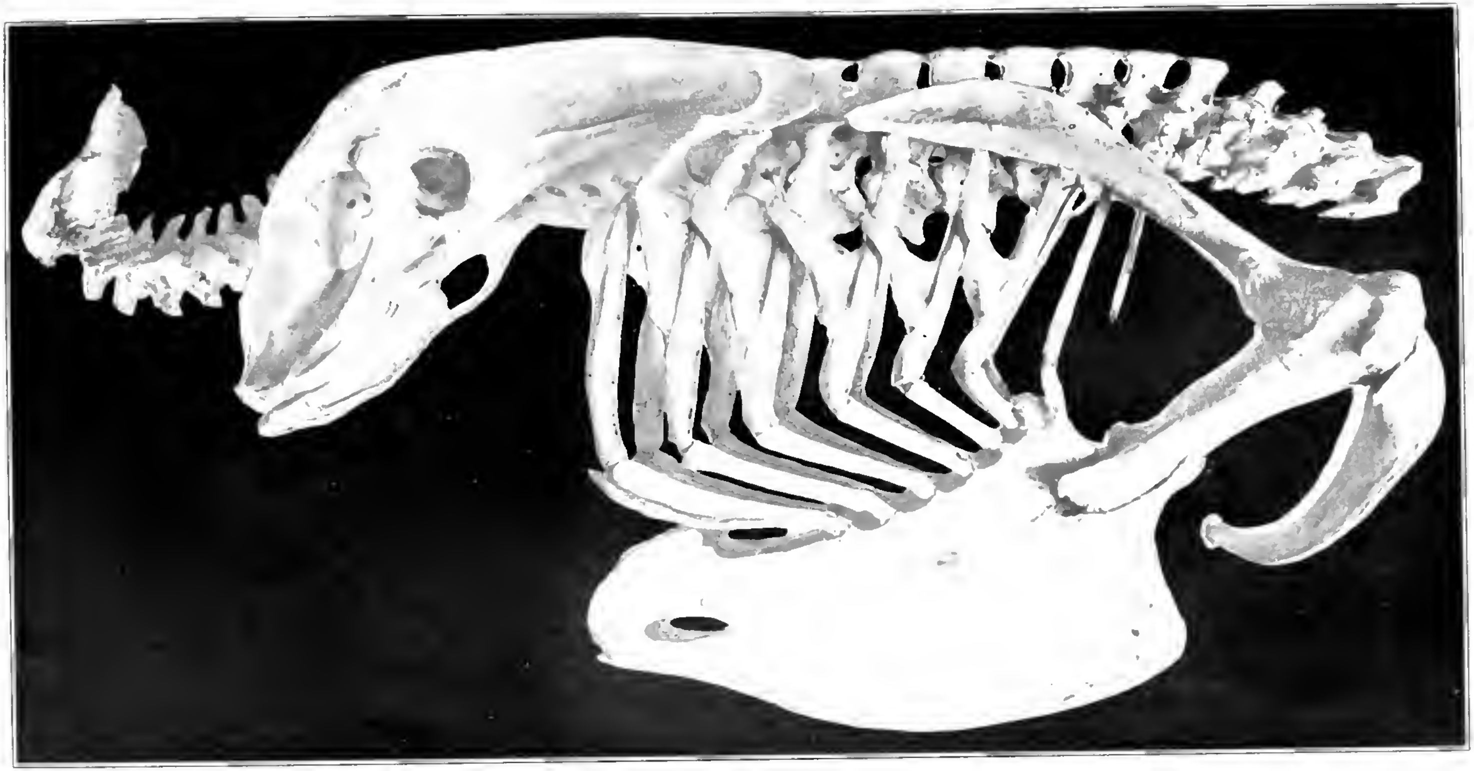


PLATE V. TRUNK SKELETON OF THRASAËTOS HARPYJA.

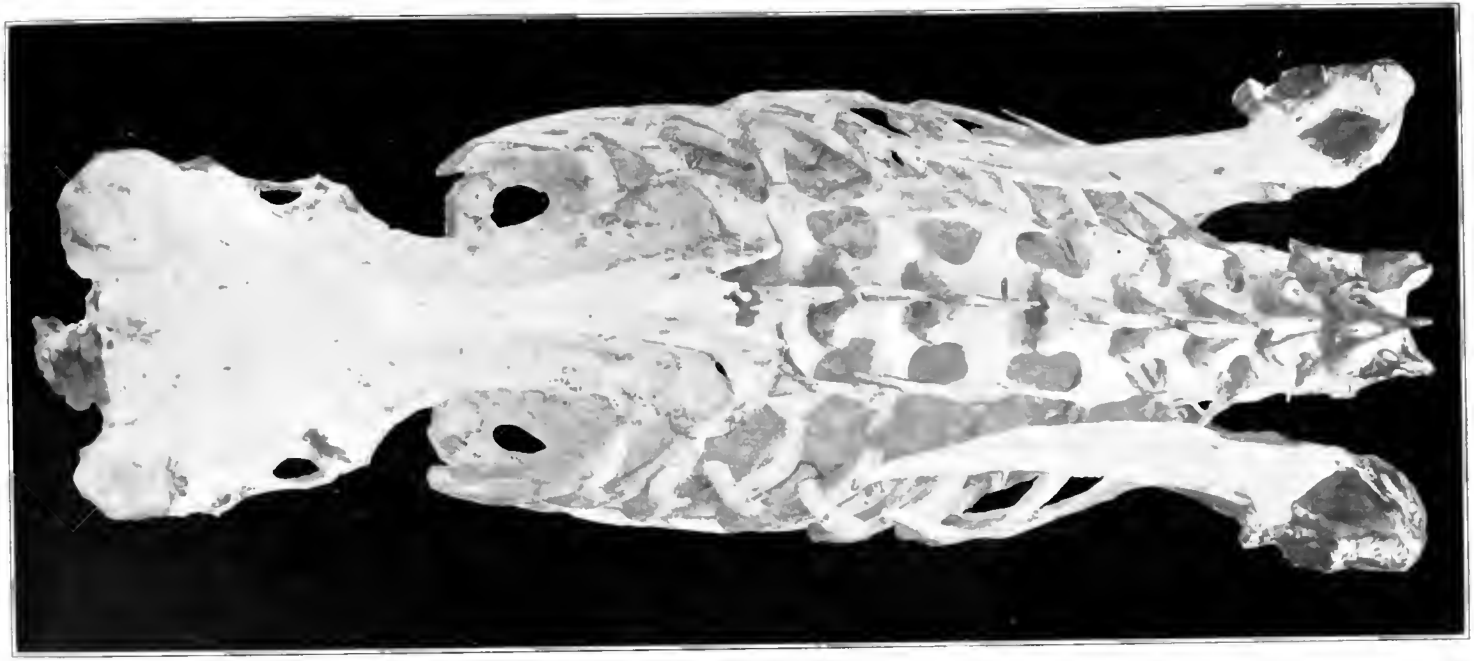


PLATE VI. TRUNK SKELETON OF PITHECOPHAGA JEFFERYI.

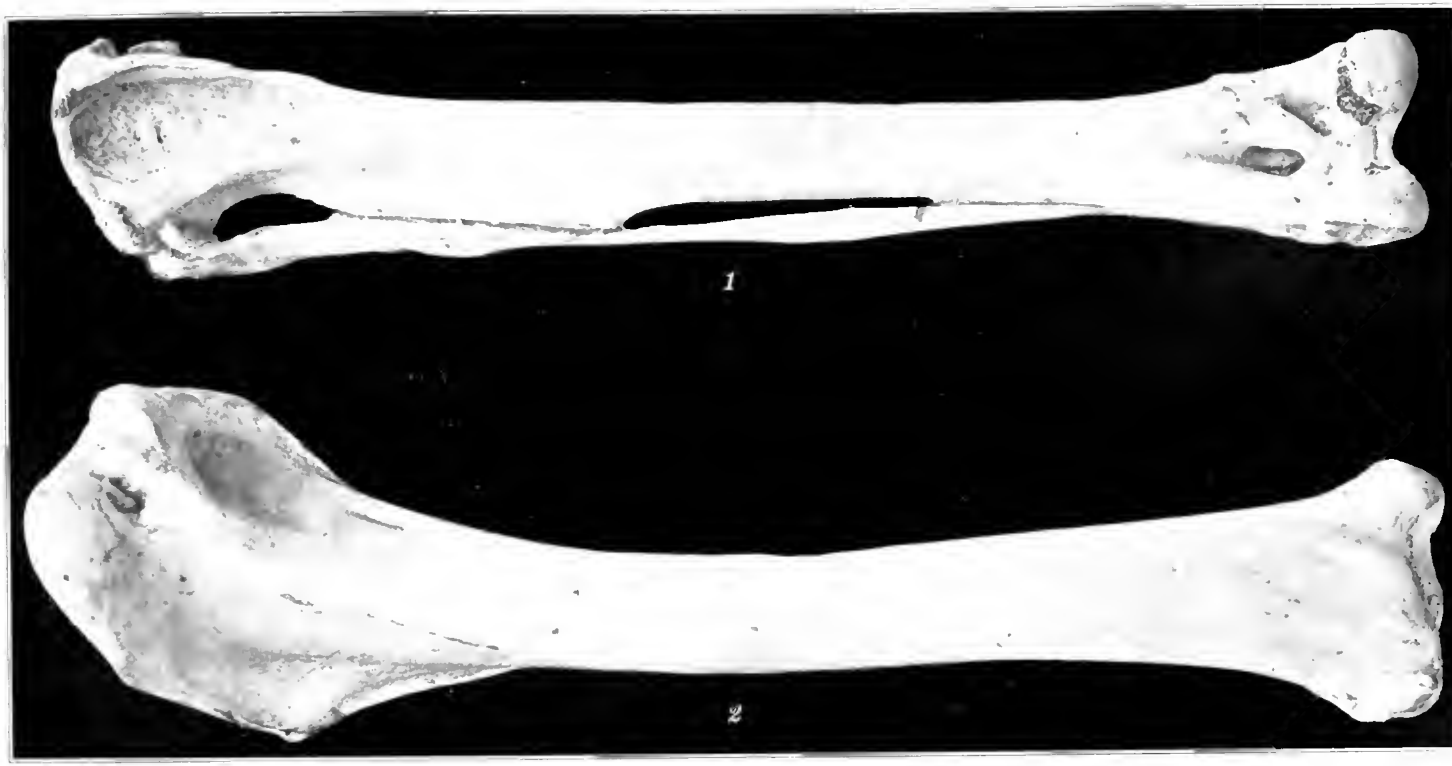



PLATE VII. THRASAETOS HARPYJA.

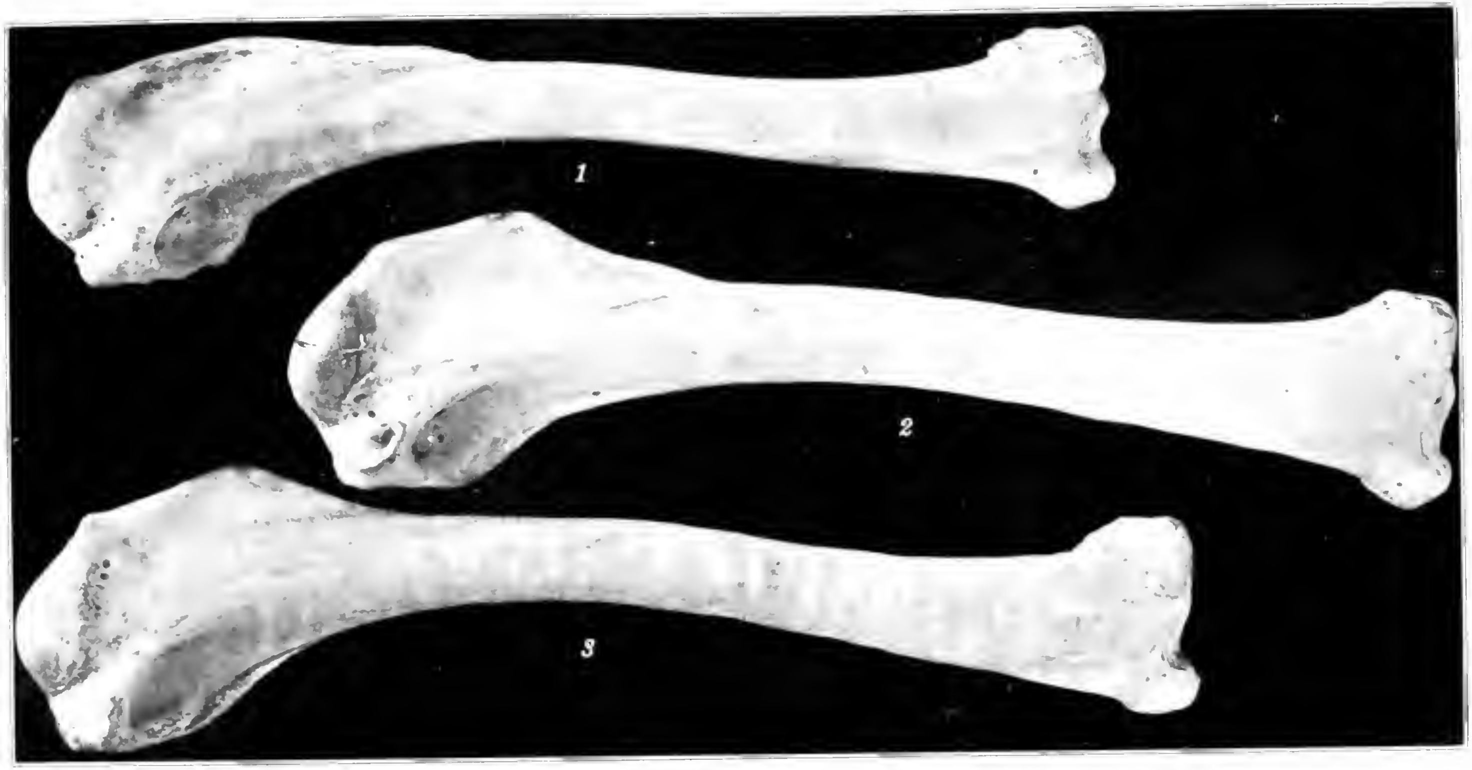



PLATE VIII. HUMERI OF THREE EAGLES.

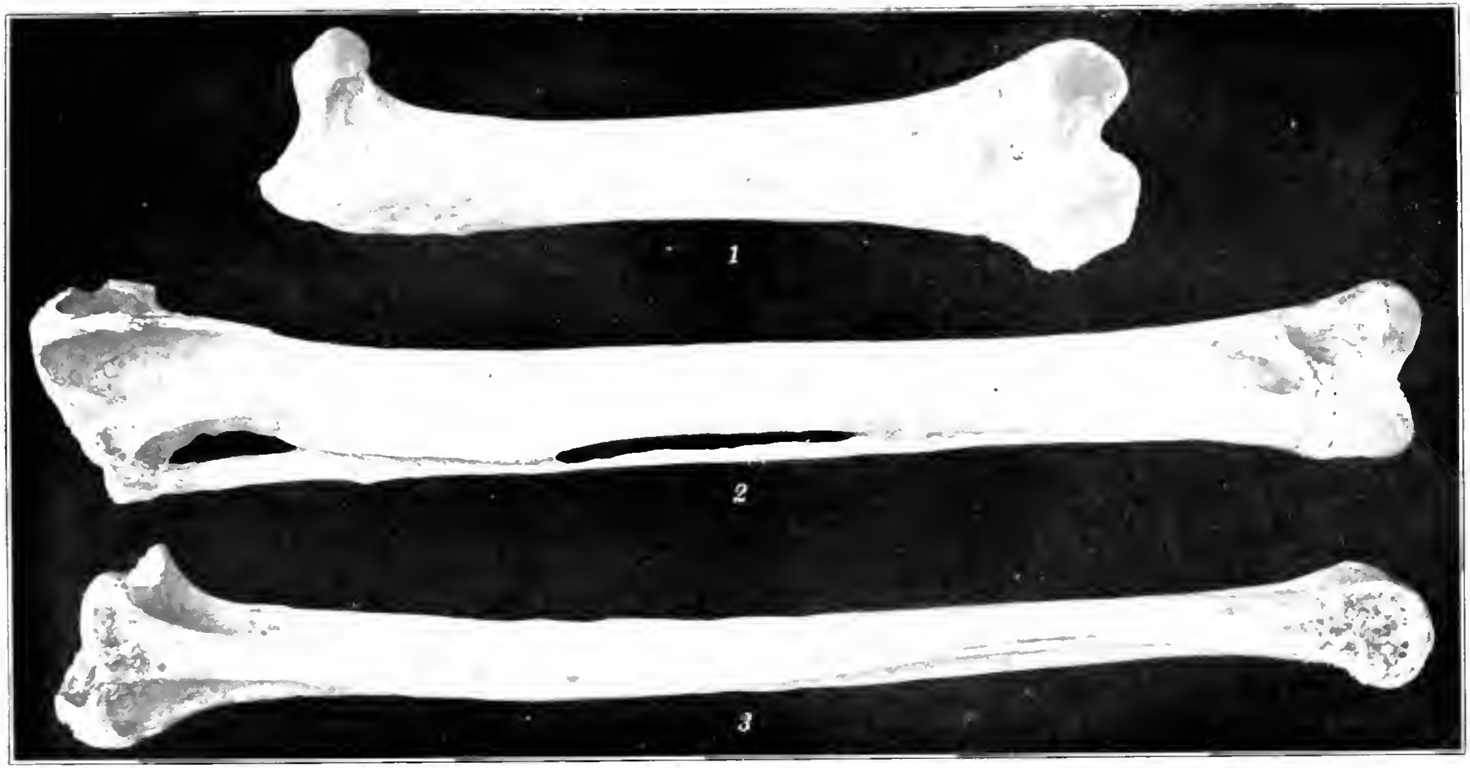



PLATE IX. LEG BONES OF PITHECOPHAGA JEFFERYI.

PLATE X. FOOT OF FITHECOPHAGA JEFFERYI.


PLATE XI. FEET OF HALIÆETUS LEUCOCEPHALUS.

# GENERAL FACTS IN THE BIOLOGY OF PHILIPPINE MOUND-BUILDING TERMITES

By LEOPOLDO B. UICHANCO

*Of the Department of Entomology, College of Agriculture, University of the Philippines, Los Baños*

FOUR PLATES

The mound-building species of Philippine termites so far known are all members of the genus *Termes*. They are common in rural and suburban places; and in caiñgin fields they are left undisturbed, although undoubtedly a menace to farming operations, both because they are always in the way and because they are prolific sources of severe anay [1] infestation. The tao tolerates the nests, not because he is too lazy to dig them out, but because a tradition current among Filipino peasants makes the *nuno* [2] the regular occupant of the mound. The nuno is a sort of wood-inhabiting spirit, believed to be normally invisible; he, however, occasionally appears to us mortals in the form of a small, unsightly, evil-looking old man, wearing a large *salacot*.[3] His every desire is a wicked one. He takes pleasure in causing human suffering; and to injure him, even though accidentally, means sickness, and often death, to the offender.

The termite mounds found in the Philippines do not reach the proportions of those met with in some other countries. In Australia, for example, termite mounds grow so large that they often appear to the traveler to be huge earthen towers. Old termite mounds in the Philippines very rarely reach a height of two meters. They generally approach a round-topped, conical shape, and are usually free from green vegetation, although they are occasionally found covered all over with a thick mat of cogon or low shrubbery. Sometimes a mound is built around or against a large tree trunk, in which case its shape becomes very irregular. The outer wall of the nest is remarkably compact, considerable force being necessary to break it open with a mattock. The main constituent of this wall is very fine clay,

[1] Local name for the termite, or white ant.

[2] Tagalog for grandfather.

[3] A native helmet, usually made of bamboo or palm leaves, and rattan.

which has probably been made firm and sticky by admixture with certain substances from the bodies of the termites. Mounds over which a large heap of grass or sticks had been burnt were, on opening, observed to have all their inhabitants, including the delicate nymphs and the eggs, absolutely unaffected by the heat.

Beneath the thick outer crust of clay are the "fungus gardens," composed entirely of a mixture of fine pellets of woody excreta and plasterlike material, which have passed out of the alimentary canals of the workers. In a typical anay mound these gardens occupy the greater part of the inner cavity; compact slabs of moist clay, with numerous irregular passageways running through them, form the partitions and, at the same time, the supports of the gardens. Each garden is composed of numerous vertical galleries formed by the intersection of the walls; the general appearance is that of a sea coral, with the upper convex margin of each partition neatly finished and the lower part either unfinished or made rugged by being bitten off. As the name indicates, the termites utilize the gardens in the cultivation of certain species of fungi, or mushrooms, to be more specific. They regularly harvest the "buttons" of the fungi, as soon as they appear, for use as food. At certain seasons of the year, during the rainy months, the mushrooms break through the outer wall of the nest and develop into full-grown plants. These mushrooms are a common sight in the regions about Los Baños on the mounds, or on the surface over underground anay nests; and they are much relished as an article of food by everybody who eats them. The local farmers know them under the general name of *mamunso*.[4]

Several theories have been proposed in connection with the periodical appearances of this mushroom. One explanation is that on the advent of a more favorable season, the fungi in the termites' gardens become so numerous that a certain number find a chance to escape and develop into perfect mushrooms before the workers have a chance to harvest the "buttons." Another is that the termites purposely allow the mushrooms to develop into mature plants in order to furnish seed for the following season. The galleries of the fungus gardens and the network of tunnels in the intervening slabs of clay also serve as nurseries, where the eggs and the young nymphs are taken care of. An upright, irregularly shaped pillar of clay, which forms the core of the nest, serves the double purpose of sup-

[4] Of or pertaining to the mound (Tagalog).

porting the series of fungus gardens and of being the main prop that prevents the outer shell of the nest from collapsing.

At least six different forms of adult individuals are present in the nest; namely, the king, the queen, the large and the small workers, and the large and the small soldiers. Each caste has a distinct function in the nest; and, due to the similarity of the termites to the true ants in community economy, they are often termed "white ants." The various castes present in each nest are the offspring of a single pair, which has settled down and mated after swarming.

The swarming of winged termites occurs after sunset or late in the evening, usually during the months between May and September. The swarms are composed of individuals of both sexes, the males for some reason far outnumbering the females. Several counts made on certain swarms of *Termes* (*Macrotermes*) *philippinensis* Oshima, in 1915, gave an average of less than five females to a hundred males. These swarms come from well-established anay nests where, at certain seasons of the year, winged individuals are produced. On certain nights, probably as a result of favorable climatic conditions, large swarms of winged termites are observed to occur at the same time in widely separated localities; for example, the campus of the College of Agriculture and the municipalities of Los Baños and Calamba. These insects are exceedingly feeble fliers and, for this reason, cannot travel far on their wings; they could not possibly have reached these very distant places from a nest located at any one spot. The more logical inference is that there occurs a simultaneous swarming from nests over a large area.

An enormous number of individuals composes a swarm; but a great many of them perish in their conjugal flight by being preyed upon by their numerous enemies—principally bats, birds, lizards, and ants. After shedding their wings, the couples run about, the male following the female by clinging fast with his mouth parts to the posterior extremity of her body, until they finally succeed in locating a fit spot in which to build their nest. This is usually under a stone or a piece of wood on moist ground, where they dig a small hollow in which they establish themselves. Some observers maintain that a group of wandering workers of the same species must fall in the way of each newly mated couple and help it establish the colony; but more sound evidence is necessary definitely to prove this assertion. The paired individuals coming down from the swarm and building a nest go

for a considerable length of time without food. About five days after starting the new home, the female begins to lay from one to five eggs, at intervals of two or three days. It takes the eggs about a month to hatch, and the adults that develop therefrom are mostly workers, only a very few soldiers being produced. Sexual individuals are not produced until later, when the colony is already well established. The nymphs of soldiers do not exhibit the characteristic appearance of their respective mature forms until about the last instar, or immediately before the insect reaches the adult stage. Nymphs of the sexual caste are larger than those of either soldier or worker and are easily distinguished by the presence of wing pads on those areas of the body where the full-grown wings are to develop later. The nymphal stage of the soldiers and workers lasts about a month; no definite observation has as yet been made in connection with that of the winged form. In about three months after the establishment of the nest, a sufficient number of small workers has been developed to start the work on a fungus garden and on the preliminary construction of the new mound which is to become the permanent home of the colony.

In a well-established nest the royal chamber is located a little below the level of the surface of the ground. It is a hollow, plano-convex chamber, with thick, irregular, clay walls and numerous passageways connecting with the adjoining parts of the nest. Within the chamber are the king and the queen, attended by a large bodyguard of soldiers and workers. Occasionally, two queens are found occupying the same chamber in a nest; but in all cases not more than one male is present. The king has not changed his appearance since he first came down from the nuptial flight; he is still very lively and is likely to slip away and escape detection unless some care is exercised in removing the royal chamber from the nest. On the other hand, the queen has changed considerably. Her abdomen is much engorged with eggs; and the abdominal tergites and sternites, once closely connected, are now situated far apart, with their connecting membranes greatly distended. The insect at this time presents a characteristic sausagelike appearance. Her activity is restricted in so far as locomotion is concerned; and she is now entirely helpless—actually a prisoner in her own cell. The workers feed her, clean her body, and look after her personal comfort. Her abdomen exhibits a succession of peristaltic movements, attended by a continuous discharge of more or less ellip-

tical eggs. A full-grown queen lays eggs at the rate of thirty to sixty a minute. The workers remove the eggs immediately after they are extruded and carry them away to be taken care of in the nurseries.

The original king does not live long, being probably replaced many times during the existence of the colony. The queen's life has been estimated to last about twenty years. Certain species of termites insure the perpetuation of their colony by providing for a substitute queen, sometimes designated neoteinic. The latter is distinguishable from the true queen by the absence of any indication of her having ever attained the power of flight. She is fully as capable of reproduction as the true queen, but does not live quite so long.

The soldiers and the workers are asexual individuals. They have no external indication of the organs of sight and never develop wings. They avoid the light and build protective covers wherever they go, though there is a species of black termites [5] which travels readily in the daylight through forests and in open places when necessary. Numerous passageways radiate in all directions, under or upon the surface of the ground, from their nests to the objects of their attack—old logs, living tree trunks, house posts, fences; in fact, all kinds of ligneous materials that may come within their reach. Accompanied by a comparatively small number of soldiers, a number of workers set out upon their work in regular processions, usually under cover of dirt tunnels. The others that remain at home are on duty attending the queen, the eggs, and the young; enlarging the mound; harvesting the crops; protecting the nest against intruding enemies (of which the worst is a species of red ant, *Solenopsis geminata* Fabr., very frequently found living in large colonies within easy reach of the mounds); and keeping the mound in a healthy and sanitary condition. To keep their nest clean, the termites maintain, or otherwise encourage, in their colony a force of scavengers, often termed "guests," consisting of beetles, earwigs, cockroaches, spring-tails, and myriapods, which continually rid the premises of waste materials.

Communication among the termites is undoubtedly carried on by means of their senses of touch and of smell. They have a remarkable ability to locate the different places in the perfectly dark nest, and can start on long journeys and search out their various necessities with an admirable degree of precision. A

[5] Probably not a mound-building species.

hole made in a tunnel or in the outer crust of the nest is sure to bring in response the soldiers' powerful mandibles protruding from within, around the edges of the break, while the workers come in succession, each carrying a small pellet of materials for repair. The workers, architects by nature, know just when a portion of their structure is not strong enough to prevent collapse, for in tunnels where the walls span out very wide to the two sides, they reënforce the weaker spots with supporting pillars of prepared earth. In a termite colony each worker is apparently his own boss; yet no confusion or trouble arises as a result, for they all seem to think, plan, and work together in perfect unison, as though they were interrelated units of one single organism—a marvelous example of the true communistic society where every effort of every individual is directed toward the general welfare, the good of the race.

# ILLUSTRATIONS

Fig. 1. A typical termite mound.

Fig. 2. Vertical section of mound.

PLATE I.

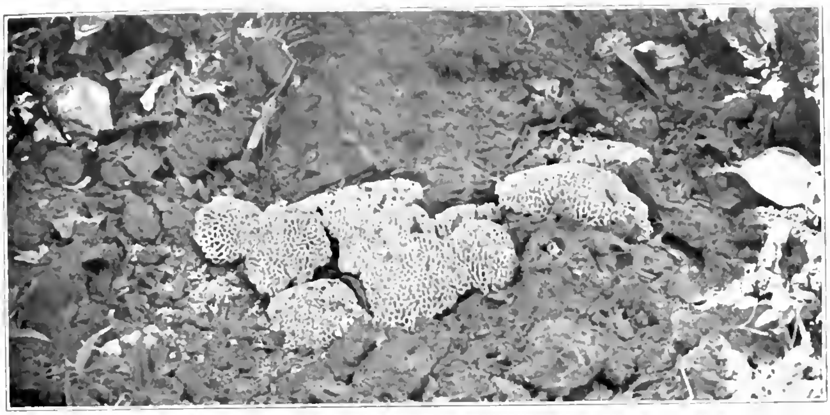


Fig. 1. A layer of fungus gardens.

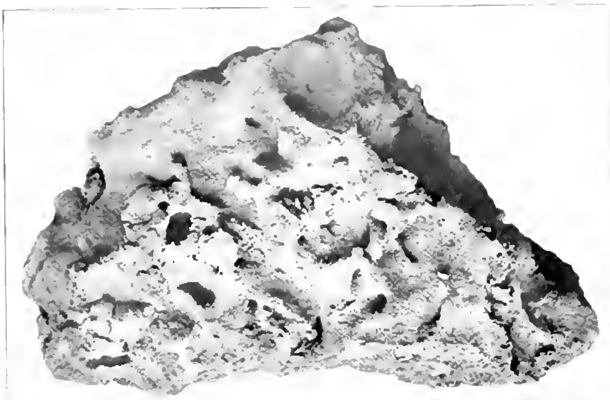


Fig. 2. Royal chamber, top view.

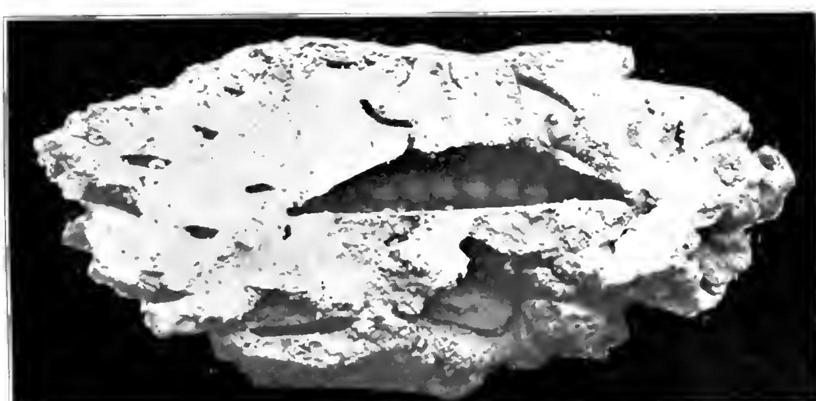


Fig. 3. Royal chamber, vertical section.

PLATE II.

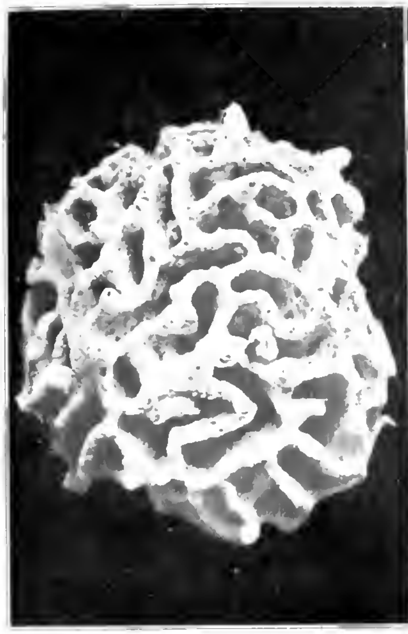


Fig. 1. A fungus garden.

Fig. 2. The royal chamber.

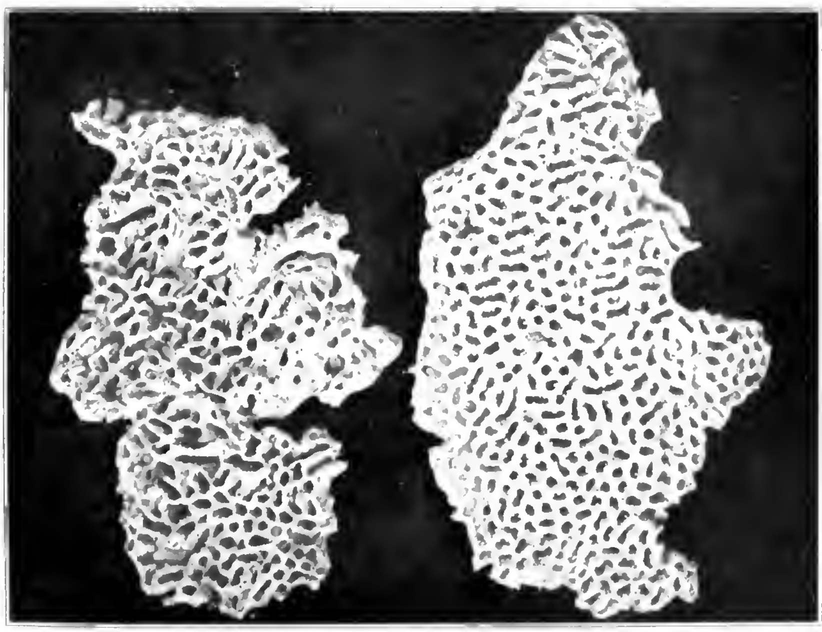


Fig. 3. A typical fungus garden.

PLATE III.

Fig. 1.

Fig. 2.

Fig. 3.

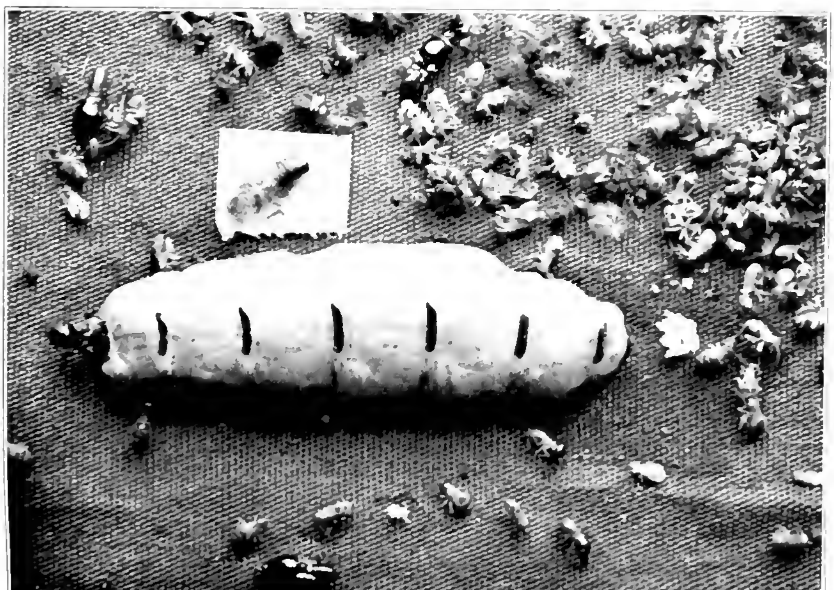


Fig. 4. The royal couple and retinue.

PLATE IV.

# THE MALAYAN MACHÆROTINÆ (CERCOPIDÆ)

By C. F. Baker

*Of the Philippine College of Agriculture, Los Baños*

THREE PLATES AND ONE TEXT FIGURE

The insects composing this group, remarkable in both structure and habit, have been latterly considered to form a subfamily in the Cercopidæ. When only *Machærota* was known, this seemed doubtful, but through other recently described genera the relationship is much more evident. The habits of members of this group distinguish them from all other Cercopidæ, and from most other insects as well; since the nymphs live in calcareous tubes, of curious form characteristic of the various species, and possess remarkable structural adaptations to life in these tubes, which remain attached to their special food plants.

Had the Enderleiniini not been included in the group, the Machærotinæ would have been easy to define, the remarkable scutellar appendage and characteristic structure of the tegmina being diagnostic. Schmidt defined the Enderleiniini as having the scutellum without spinous appendage, but elongate caudad and reaching or exceeding the apex of the abdomen. However, *Machæropsis*, as illustrated by Lallemand,[1] has a scutellum not reaching half the length of the abdomen, though in structure otherwise it appears to be somewhat machærotine; and one of Schmidt's most recent genera, *Modiglianella*, is very close to cercopid genera like *Quinquatrus* Distant and *Hindola* Kirkaldy (=*Carystus* Stål). It seems, arguing from structure alone, that the tribe Enderleiniini should be transferred to the Aphrophorinæ, which already includes far more diverse elements, the latter subfamily to be divided into a number of coördinate tribes.[2] This would not preclude the possibility of the true Machærotinæ being offshoots from Enderleinia-like forms. The

[1] Cercopidæ of the Genera Insectorum (1912).

[2] In Fauna Brit. India, Rhynch. 6 (1916) 184, Distant describes a new genus, *Conditor*, of which he says, "Allied to *Machæropsis*." It does not, however, belong in the same tribe with *Machæropsis* (Enderleiniini), but is apparently closely related to *Pachymachærota* in the Machærotini.

present paper will deal only with the true Machærotinæ known from Malaya.

The first species known in this group was *Machærota ensifera* Burmeister, described in 1835, from Manila. In 1907 [3] Schmidt presented a monograph of the group, separating it into four tribes and recognizing eight genera. In 1912 the same [4] author added two genera, *Modiglianella* from Sumatra and *Neuromachærota* from German East Africa. Two Australian genera, *Polychætophyes* and *Pectinarophyes*, were described by Kirkaldy [5] in 1906, though these were not included in Schmidt's monograph.

*Machæropsis* Melichar is known only from Ceylon, *Enderleinia* Schmidt only from Togo, and *Pachymachærota* Schmidt from Australia and Sumba. Therefore, half of the known genera and the larger proportion of the known species come from the Malayan Region. Since this region, as well as Australasia, is but little explored as to the Homoptera, the known forms of this group probably represent but a small part of the genera and species in existence. So far, *Machærota* appears to be the only genus of wide distribution, species of it being found from India (with Ceylon and Andamans) and China, to the Philippines, Malaya, and Flores. It will undoubtedly be found still farther to the southeast, through the Moluccas. New Guinea will almost certainly yield interesting members of the group.

In the present paper, two new Philippine species are added to *Machærota; Grypomachærota* is shown to be represented by two new species in Borneo and to occur in Penang; and *Maxudea* is for the first time recorded from the Malay Peninsula.

The Machærotinæ present a most interesting field for anatomical study. The sclerites of the thorax are deeply and sharply marked, and present most remarkable forms. A sounder classification will undoubtedly be possible when these have been exhaustively studied. The hind femora (? in *Maxudea*) usually have a strong tubercle beneath at base. The membranous appendix of tegmina is usually transversely fluted. The impressed horizontal suture in front of ocelli is the actual anterior margin of vertex, the sutures passing forward from its extremities being the lateral margins of frons. The upper portions of the cheeks are thus distinctly superior. It thus results that the projection of the head in *Grypomachærota* and *Sigmasoma* is

[3] Ent. Zeitg. Stettin **68** (1907) 165–200.
[4] Ent. Zeitg. Stettin **73** (1912) 173–178.
[5] Bull. Haw. Sugar Plant. Exp. Sta. **1** (1906) 384–386.

entirely referable to the frons. For purposes of description in this paper, however, the entire superior surface of the head between the eyes is termed vertex.

### Subfamily MACHÆROTINÆ sensu stricto

*Key to the tribes.*

$a^1$. Body slender; scutellum arched and with a distinct dorsal furrow; pronotum without produced lateral angles.
  $b^1$. Frons not produced above; hind tibiæ without a tooth.... Machærotini.
  $b^2$. Frons acutely produced above; hind tibiæ with one tooth .Sigmasomini.
$a^2$. Body very thick and stout; scutellum nearly flat and with dorsal furrow subobsolete; pronotum with lateral angles produced into high thin laminæ ........................ Maxudeini.

### Tribe MACHÆROTINI

This tribe includes but one Malayan genus, so far as known.

### Genus MACHÆROTA Burmeister

*Key to the species.*

$a^1$. Claval vein apically forked.
  $b^1$. Body of scutellum not high arched posteriorly, its greatest depth much less than length; vertex anteriorly broadly rounded; spatulate scutellar furrow about half length of body of scutellum (Plate I, figs. 1 and 9)........................ M. notoceras Schmidt.
  $b^2$. Body of scutellum high arched posteriorly, its greatest depth as seen from side about equaling length; vertex anteriorly subangulate; spatulate scutellar furrow much more than half length of body of scutellum (Plate I, figs. 2, 3, and 10; Plate II, fig. 1).
M. philippinensis sp. nov.
$a^2$. Claval vein simple.
  $b^1$. Median cell short and broad; length of vertex far less than width between eyes posteriorly; spatulate scutellar furrow less than half length of body of scutellum.
    $c^1$. Length of body of scutellum distinctly greater than that of pronotum; length of scutellar spine less than once and a half the length of body of scutellum; ocelli nearer to median line than to eyes (Plate I, figs. 4, 5, 11, and 14; Plate II, figs. 3 and 4) M. ensifera Burm.
    $c^2$. Length of body of scutellum subequal to that of pronotum; length of scutellar spine a little less than twice length of body of scutellum; ocelli as near median line as to eyes (Plate I, figs. 6 and 12; Plate II, figs. 5, 6, and 13)............ M. luzonensis Schmidt.
  $b^2$. Median cell long and narrow; length of vertex subequal to width between eyes posteriorly; spatulate scutellar furrow much more than half length of body of scutellum (Plate I, figs. 7, 8, and 13; Plate II, figs. 2, 7, and 10)............ M. fusca sp. nov.

In *Machærota notoceras*, *M. philippinensis*, and *M. ensifera* the sharp upper border of the scutellar spine is extended into the scutellar furrow as a sharp median carina to half its length, whereas in *M. luzonensis* and *fusca*, it scarcely enters this

furrow. All of the species possess a small, thin, semitranslucent, decolored spot on the upper border of the spine near its base. The depth of coloring is widely variable in all of the species, and the males are always smaller and darker than the females. Structural characters only should be depended upon for classification. What appear to be the normal color forms are described in the following pages.[6]

Machærota notoceras Schmidt.

*Machærota notoceras* SCHMIDT, Ent. Zeitg. Stettin 68 (1907) 192.

This species is common on Penang Island, Wellesley Province, Straits Settlements.

Machærota philippinensis sp. nov.

*Female.*—Length to end of abdomen, 4.5 millimeters; to ends of tegmina, 6; to end of spine, 7.

Color chocolate; frontal ridge and apex of frons piceous; sides of frons with ten horizontal yellowish stripes, these with numerous short, coarse, appressed white hairs; second antennal joint rufous with white distal border; sides of body of scutellum with curved ivory-white areæ, reaching from anterior lateral angles to anterior extremity of scutellar groove; the thin margins of scutellar groove alternately black and yellow spotted; a few minute black dots on posterior lateral walls of scutellar body; posterior border of scutellar body below spine ivory-white, the stramineous spine separated from brown scutellar body by an irregular piceous border. Veins of tegmina stramineous with scattering piceous dots, the tegmina suffused with very pale stramineous, the costa brown near base. Abdominal dorsum black, first tergite yellow; venter largely piceous; tibiæ and tarsi paler brown than femora.

Frons very minutely punctate-rugose, near clypeus and with clypeus, coarsely punctate-rugose; median ridge broad and strong on upper half of frons; vertex sculptured like the frons. Pronotum deeply, coarsely reticulate-punctate, this becoming weaker near anterior border; the low weak median ridge is continuous throughout; on either side anteriorly are two short, broad, oblique, shallowly depressed areæ, which do not reach anterior margin, and are thickly, minutely punctate or shagreened within. Body of scutellum coarsely reticulate-punctate; scutellar furrow

[6] Characters given in the keys are not repeated in the descriptions, so that for complete diagnoses of the species, the two should be combined.

reticulate within, the lateral margins high and thin; spine with its point about 1 millimeter above apex of tegmina.

*Male.*—Length to end of abdomen, 3 millimeters; to end of tegmina, 4.5; to end of spine, 5.5.

Colors deeper than in the female, the pronotum almost piceous. The spine is more or less minutely dotted, and the lateral yellow marks on body of scutellum are abbreviated posteriorly.

This is a common species at Los Baños and on Mount Maquiling, both localities in Laguna Province, Luzon Island, Philippine Islands.

Machærota luzonensis Schmidt.

*Machærota luzonensis* SCHMIDT, Ent. Zeitg. Stettin 68 (1907) 189.

*Female.*—Length to end of abdomen, 4 millimeters; to ends of tegmina, 6; to end of spine, 7.

Color stramineous; spine, and scutellum caudad, pale reddish brown; legs yellowish. Frons yellowish, with eight horizontal piceous bands on either side, and with no median dark color except above; scutellum with an indistinct, median piceous stripe; posterior yellow border of body of scutellum broader below, the intramarginal, deeply depressed line piceous; the curved yellowish marks on sides of body of scutellum very indistinct; a few dark dots on borders of scutellar groove. Abdomen stramineous, ovipositor piceous.

Frons nearly smooth, indistinctly shagreened, the lower border, with clypeus, more coarsely sculptured; face almost entirely without appressed white pubescence. Pronotum coarsely reticulate-punctate except near anterior margin, but the reticulations are not sharp; the four slightly depressed oblique areæ near fore margin short, minutely roughened, and piceous; the median ridge sharp and high. Reticulate character of puncturation less evident on body of scutellum; spine strongly curved at base, its point a millimeter above the apex of tegmina.

In all of the Philippine material before me, there appear to be but two specimens that approximately fit the original description of Schmidt's species. These are from Davao, Mindanao Island, Philippine Islands.

**Machærota ensifera** Burm.

*Machærota ensifera* BURMEISTER, Handb. Ent. 2[1] (1835) 128.

The disposition of colors on pronotum in longitudinal stripes clearly marks this species in all of its various light and dark phases. The common form in Luzon is pale in color, but very

dark-colored forms come from Palawan. The palest forms in my collection were taken in Imugan, Nueva Vizcaya Province, Luzon. The very broad, shining, black, median portion of face, broader above, is also characteristic in all color phases; in the Luzon forms this dark color is lacking on the lower frons and on clypeus, whereas in the dark Palawan forms it is broad throughout; only rudiments of horizontal, lateral, frontal stripes are present in any of the color phases. The four slightly depressed and finely sculptured oblique areæ near anterior border of pronotum are concolorous. The spine is scarcely curved where it joins body of scutellum, and its point is about 1.5 millimeters above apex of tegmina.

Abundant throughout the Philippine Islands.

**Machærota fusca** sp. nov.

*Female.*—Length to end of abdomen, 5 millimeters; to ends of tegmina, 7.25; to end of spine, 8.5.

Color stramineous to chocolate, to piceous, and strongly contrasted. Entire face black; vertex, pronotum, and scutellum chocolate; posterolateral areæ of pronotal disk stramineous; lateral angles of pronotum shining piceous; lateral areæ of vertex and short longitudinal stripes inclosing the ocelli posteriorly, stramineous; lateral yellow stripes on body of scutellum long, straight, more than two-thirds length of scutellar body and somewhat broader caudad; posterior border of scutellar body very narrowly and shortly yellowed; scutellar spine piceous. Pleuræ stramineous; venter piceous to brown; legs brown, femora stramineous at apex, fore and middle tibiæ stramineous at base, hind tibiæ stramineous on basal three-fourths. Abdomen stramineous above, with broad longitudinal lateral areæ brownish, the narrow venter brownish. Tegmina suffused with stramineous in the region of apical cells, where the veins are pale brown; the remainder of corium subhyaline with piceous veins.

Frons shining and nearly smooth except apically, laterally with subobsolete indications of a few horizontal lateral grooves; clypeus subrugose. Supra-antennal areæ of vertex foveate; frontal area of vertex depressed and with a delicate median carina, the true vertex rugose between the ocelli. Pronotum very coarsely reticulate-punctate except near fore margin, the reticula not sharp; the four finely sculptured depressed areæ near anterior margin very small; median ridge of pronotum weak, becoming obsolete posteriorly. Body of scutellum as coarsely sculptured as pronotum but more irregularly; scutellar furrow

cross wrinkled within, and with borders but little raised; lower posterior angle of posterior border of scutellum unusually prominent. Spine strongly curved, its point 1 millimeter above the apex of tegmina.

Two females of this fine species were taken at Baguio, Mountain Province, Luzon, Philippine Islands.

Tribe SIGMASOMINI

*Key to the genera.*

$a^1$. Vertical projection of head very long and sword-shaped, the head thus longer than pronotum .......... Sigmasoma Schmidt.

$a^2$. Vertical projection of head shortly acute, the head much shorter than pronotum .......... Grypomachærota Schmidt.

## Genus SIGMASOMA Schmidt

**Sigmasoma bifalcata** Schmidt.

*Sigmasoma bifalcata* SCHMIDT, Ent. Zeitg. Stettin **68** (1907) 181.

This remarkable insect was described from Java, but similar forms will probably be discovered in other parts of Malaya also.

## Genus GRYPOMACHÆROTA Schmidt

Schmidt [7] describes but one species of this genus, *G. turbinata*, crediting it to Java, Sumatra, and Borneo. Due to the very imperfect figures presented by him, and his very insufficient description, it may be fairly questioned if all of his material belongs to one species. As shown hereinafter, some species which present an extraordinary similarity in color, are completely distinct structurally. Schmidt's failure to give full structural details makes it difficult to compare *G. turbinata* with the three species recorded herein from Borneo.

*Key to the species.*

$a^1$. Medial cell about five times as long as wide and far longer than stem vein; anterolateral and posterolateral margins of pronotum deeply incurved; length of frons above eyes greater than length below antennæ; posteroinferior angle of scutellum high above lower margin and minutely acute; color pale, darker punctured; face pale with dark crossbars (Plate II, figs. 8, 9, and 11; III, figs. 1, 4, 5, and 8). G. borneensis sp. nov.

$a^2$. Medial cell little more than twice as long as wide or less, and shorter than stem vein; anterolateral and posterolateral margins of pronotum not deeply incurved; length of frons above eyes less than length below antennæ; posteroinferior angle of scutellum in line with lower margin, and large, obtuse; color dark, head black.

$b^1$. Scutellar spine not strongly decurved, its apex far above apex of tegmina.

[7] Ent. Zeitg. Stettin **68** (1907) 183.

c². Scutellar spine but slightly longer than scutellum; height of head above eye equal to depth of eye .................. G. turbinata Schmidt.

c². Scutellar spine a half or nearly a half longer than scutellum; height of head above eye greater than depth of eye (Plate II, fig. 14; Plate III, figs. 2 and 6) .......................... G. tricolor sp. nov.

b². Scutellar spine strongly decurved, its apex near apex of tegmina; height of head above eye much less than depth of eye (Plate II, figs. 12 and 15; Plate III, figs. 3, 7, 9)............ G. breviceps sp. nov.

Grypomachærota borneensis sp. nov.

*Female.*—Length to end of abdomen, 5 millimeters; to ends of tegmina, 6.5; to end of spine, 7.

Stramineous; lower part of face, sternum, and venter piceous, the latter sometimes paler; frons piceous basally and apically, the middle two-fourths stramineous, and each side with eight narrow oblique piceous stripes; vertex dark brown except the stramineous superior cheek areæ, an area connecting ocelli, and the postocular areæ. Punctures of pronotum brown, this rendering conspicuous the stramineous reticula, median carina, and posterolateral borders. Scutellum and base and lower border of spine pale brown; lateral pale stripes on body of scutellum straight, oblique, passing backward and upward to beyond middle; median dorsal line on body of scutellum and entire upper portion of spine except at base (where it is piceous), stramineous; posterior margin of body of scutellum shortly and broadly yellowish and immediately above this piceous; the inferolateral border also narrowly yellowish. Tegmina slightly suffused with stramineous apically, the veins brown to piceous. Legs brown to piceous, apices of femora and nearly all of tibiæ stramineous.

Frons finely, transversely, rugosely wrinkled and shining, more coarsely sculptured below and on clypeus; frons evenly convex on lower half, but with a strong median carina on upper half, this reaching the upper angle of appendage, where the lateral margins are also sharply carinate. Vertex horizontally rugose, with a median carina which apically becomes sharply raised and double; lateral areæ of frontal portion of vertex concave. Pronotum coarsely reticulate-punctate except near anterior border, the reticula not sharp; four small, depressed, oblique, finely sculptured areæ near fore margin as in *Machærota*. Scutellum sculptured like pronotum, the furrow cross wrinkled and with the upper carina of spine scarcely entering it; spine at base with lateral disks sharply longitudinally depressed, its point 1.5 millimeters above apex of tegmina.

This is a common species at Sandakan, British North Borneo.

Grypomachærota tricolor sp. nov.

*Female.*—Length to end of abdomen, 4 millimeters; to end of tegmina, 5.5; to end of spine, 6.5.

Color black, with red-brown spine, short yellow lateral marks and narrow yellow posterior border of scutellum; tegmina with piceous veins, these apically smoky bordered.

Frons shining, minutely, irregularly, transversely rugose, a sharp median carina only on upper fourth where the lateral margins of appendage are very shortly carinate; clypeus coarsely rugose. Vertex strongly transversely wrinkled, with a short double median carina near apex; lateral areæ of frontal portion of vertex convexly rounded. Pronotum thickly, very coarsely reticulate-punctate, more weakly near fore margin, the reticula sharp; a weak median carina on apical third only; the four small depressed areæ near fore margin rather narrow and elongate. Scutellum sculptured like pronotum; the furrow short, broad apically, and very shallow; lateral surfaces of scutellum below furrow strongly depressed; the lateral depressions on base of spine very deep, foveate; apex of spine 2 millimeters above apex of tegmina.

This very distinct species occurs at Sandakan, British North Borneo.

Grypomachærota breviceps sp. nov.

Length to end of abdomen, 3.5 millimeters; to ends of tegmina and of spine, 5.

Black, with red-brown spine, short lateral yellow marks on scutellum and short yellowish posterior border; legs brownish; tegmina apically suffused with stramineous and with brownish veins; corium transparent, with piceous veins.

Frons shining, finely transversely rugose, entirely without median carina, and with upper lateral carinæ of appendage very weak; clypeus more coarsely sculptured. Vertex finely transversely wrinkled and without median carina. Pronotum and scutellum sculptured as in *G. tricolor;* sides of scutellum below furrow not strongly or broadly depressed, the posterior submarginal impressed line in this species being a long, broad fovea; base of spine laterally not deeply foveate; the very strongly curved spine approaches ends of tegmina within a half millimeter, and does not pass the ends of tegmina, thus differing from all other Malayan Machærotini.

Specimens of this species were collected on Penang Island,

Wellesley Province, Straits Settlements. One might be inclined to place this with *G. tricolor* on color alone, but its structure is very different.

Tribe MAXUDEINI

### Genus MAXUDEA Schmidt

From the viewpoint of species, the same difficulty pertains to this remarkably distinct genus as to *Grypomachærota*. The fig-

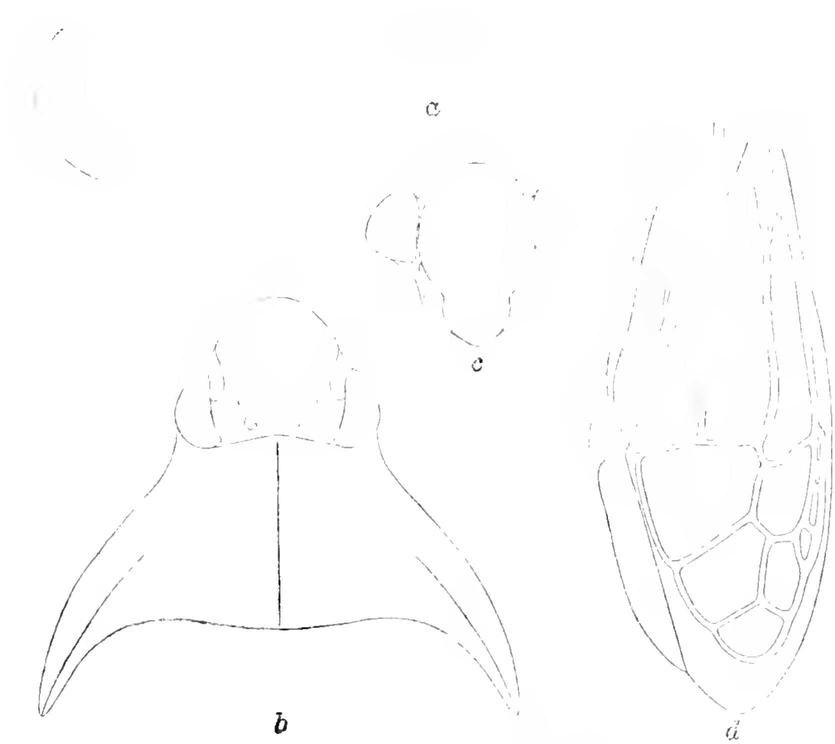



FIG. 1. *Maxudea schmidtii* sp. nov.; *a*, lateral view of head, pronotum, and scutellum; *b*, dorsal view of head and pronotum; *c*, face; *d*, tegmen.

ure and the description given by Schmidt are exceedingly crude. His lateral view of the insect is a quartering one with the head turned slightly away, so that it is impossible to secure exact

proportions of scutellum or of pronotal laminæ. The structure at the base of the scutellar spine as shown for the Sumatran species described by Schmidt,[5] *Maxudea crassiventris*, is so entirely different from that of a species obtained from Penang, that it is necessary to maintain the latter as distinct, at least until better structural data as to *M. crassiventris* can be secured.

*Key to the species.*

$a^1$. Lower margin of scutellar spine, above posteroinferior angle, strongly concave .......................................... M. crassiventris Schmidt.

$a^2$. Lower margin of scutellar spine, above posteroinferior angle, straight. M. schmidtii sp. nov.

Maxudea schmidtii sp. nov.

*Female*.—Length to end of abdomen, 6.5 millimeters; to ends of tegmina, 7.5; to end of spine, 8; breadth from tip to tip of pronotal laminæ, 5.

Color largely piceous, the pronotal laminæ shining. Face stramineous, a broad median stripe and lower third of frons and clypeus black; lateral portions of frons with about eight dark horizontal lines; vertex stramineous with dark sutures; the frontal horizontal lines continued to ocellar (true frontal) transverse suture. Anterior portion of pronotum stramineous, with four dark spots; disk of pronotum piceous, laminæ black. Scutellar body stramineous with dark punctures, without yellow lateral marks or yellow posterior margin, the spine and inferolateral margins of scutellar body chocolate. Abdomen piceous, the segments with paler margins. Legs reddish brown, basal two-thirds of femora black. Tegmina suffused with stramineous, veins brownish, darker basally.

Frons shining, irregularly shallowly roughened, the horizontal lines being distinct shallow furrows; clypeus coarsely transversely wrinkled. Frontal portion of vertex with an acutely triangular median depression just in front of ocellar suture. Pronotum thickly, coarsely reticulated punctate except near anterior margin, the reticulæ and median carina sharp (stronger anteriorly); the four small depressed areæ near fore margin are irregularly subcircular; anteriorly and posteriorly the flattened laminæ are sharp margined; subparallel with anterior margin of lamina, and near to this margin, a sharp carina passes from disk of pronotum to tip of lamina, forming a sulcus between

[5] Ent. Zeitg. Stettin **68** (1907) 176.

this and margin. Scutellar body sculptured like pronotum, the area of scutellar furrow slightly depressed, without raised margins, the strong reticula here greatly lengthened horizontally to form a series of horizontal carinæ; inferoposterior margin practically absent, the normal inferoposterior tooth of the other Machærotinæ adjoining the base of the spine. All pleuræ strongly rugose; seven tergites thickly, finely rugose-punctate; lower surface of femora bisulcate. Apex of spine 3 millimeters above ends of tegmina.

A specimen of this unique insect was taken on Penang Island, Wellesley Province, Straits Settlements; this is the first record, belonging to the Asian mainland, for this genus.

# ILLUSTRATIONS

## PLATE I



## PLATE II

PLATE III

FIG. 1. *Grypomachærota borneensis* sp. nov., lateral view of head, pronotum, and scutellum.
2. *Grypomachærota tricolor* sp. nov., lateral view of head, pronotum, and scutellum.
3. *Grypomachærota breviceps* sp. nov., lateral view of head, pronotum, and scutellum.
4. *Grypomachærota borneensis* sp. nov., as seen when dorsum of pronotum is horizontal.
5. *Grypomachærota borneensis* sp. nov., as seen when surface of vertex is nearly horizontal.
6. *Grypomachærota tricolor* sp. nov., as seen when surface of vertex is nearly horizontal.
7. *Grypomachærota breviceps* sp. nov., as seen when surface of vertex is nearly horizontal.
8. *Grypomachærota borneensis* sp. nov., face.
9. *Grypomachærota breviceps* sp. nov., face.

TEXT FIGURE

FIG. 1. *Maxudea schmidtii* sp. nov.; *a*, lateral view of head, pronotum, and scutellum; *b*, dorsal view of head and pronotum; *c*, face; *d*, tegmen.

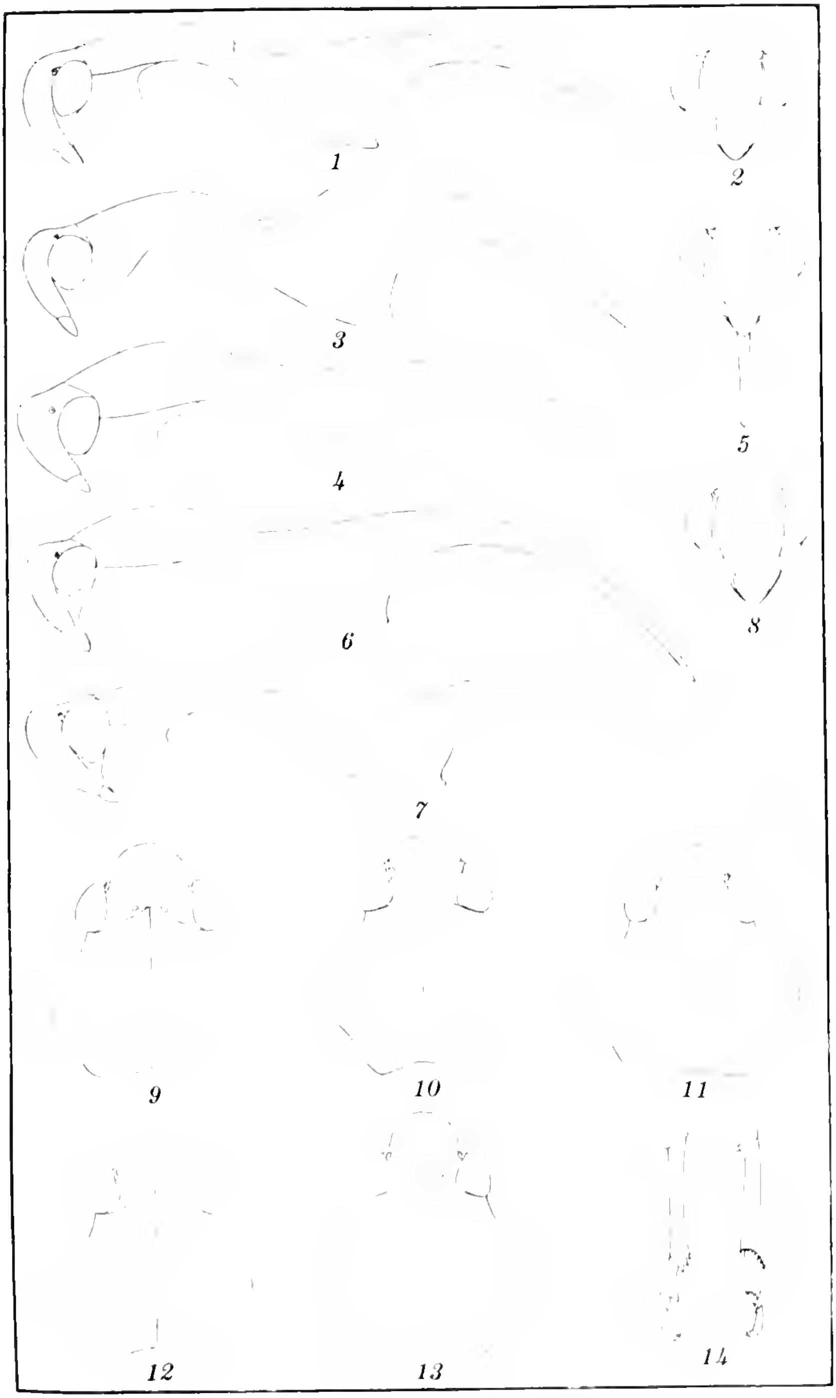



PLATE I. MALAYAN MACHÆROTINÆ.

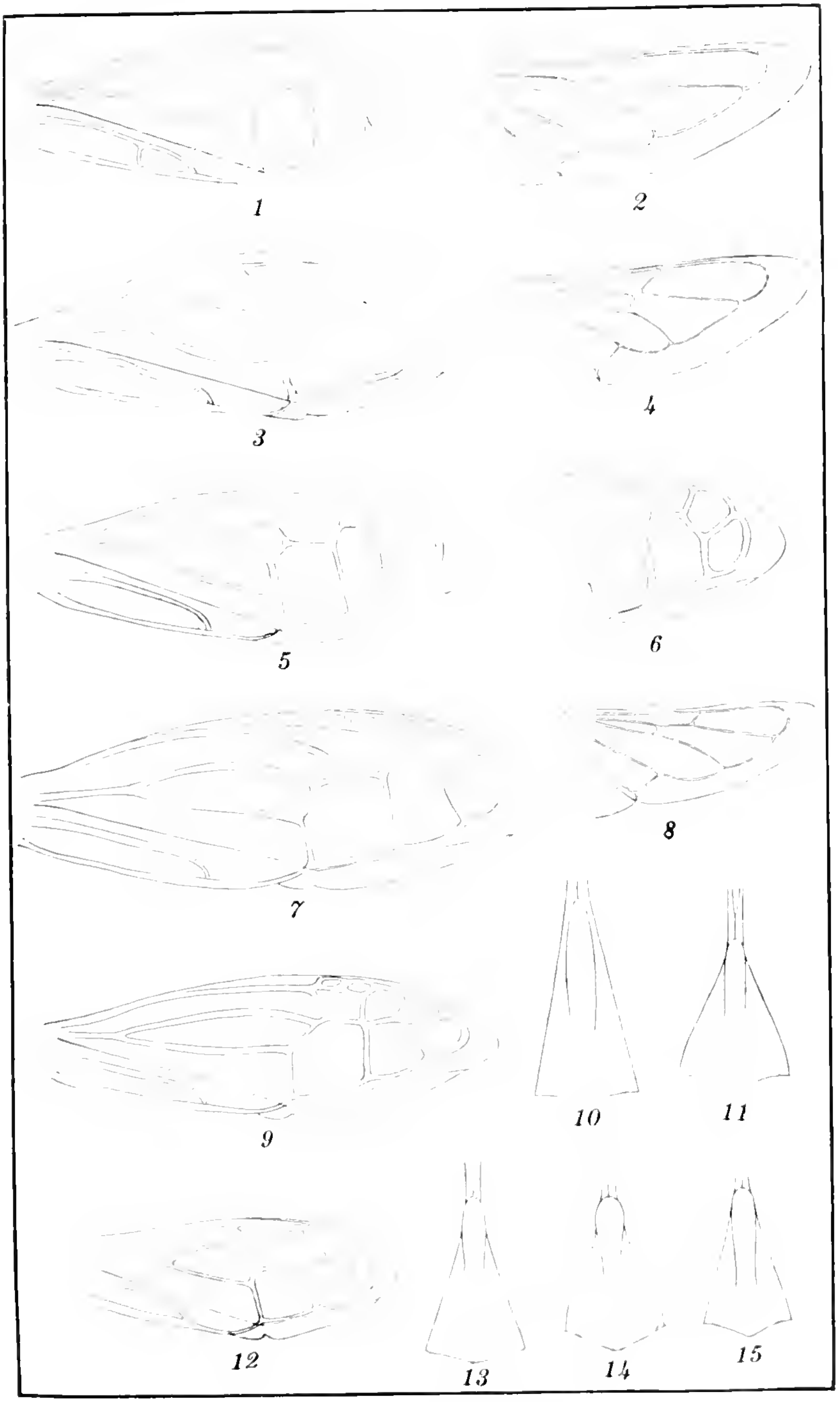


PLATE II. MALAYAN MACHÆROTINÆ.

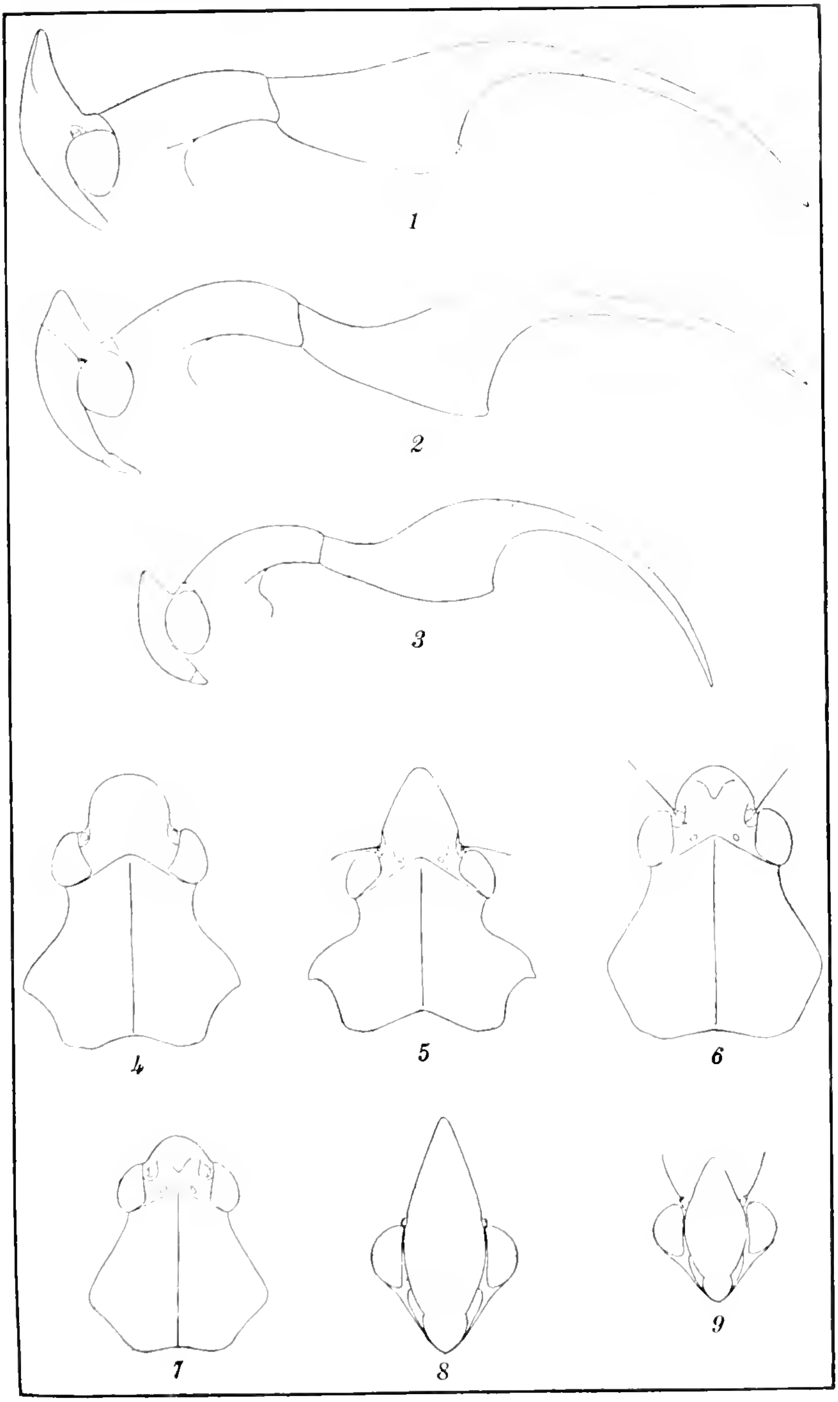



PLATE III. MALAYAN MACHÆROTINÆ.

# HABITS OF TROPICAL CRUSTACEA: III

By R. P. Cowles

*Of the Department of Zoölogy, College of Liberal Arts, University of the Philippines, Manila*

ONE PLATE

## HABITS AND REACTIONS OF HERMIT CRABS ASSOCIATED WITH SEA ANEMONES

The hermit crabs of the Philippine Islands form one of the most interesting groups of the tropical Crustacea on account of their peculiarities in structure and habits. Some of these hermits have an asymmetrical abdomen, of such a shape that the crab can insert it into the empty, spirally coiled shell of a mollusk and carry the shell about as a protection against enemies. Some hermit crabs of this kind spend practically all their lives in the sea among the rocks and the corals of rather deep water; some live close to the shore in shallow water; and others live far inland, visiting the sea only during the breeding period, at which time they usually exchange their old shells for new ones. Other hermit crabs have a straight, symmetrical or almost symmetrical abdomen; one of these, *Pylocheles miersii* Alcock and Anderson, lives in the sea and inhabits a joint of bamboo. Another kind, *Birgus latro* Linnæus, the coconut, or robber, crab, lives on land, carries no mollusk shell, and like the ordinary land hermits visits the sea only occasionally and possibly only at the breeding time.

While the peculiar anatomy and fitness for the environment of the hermit crabs are of interest, certain habits of these Crustacea are even more interesting. The hermit begins life in the sea; and, if it is of the ordinary kind that carries a spirally coiled mollusk shell, it seeks and enters one of a size suitable to its body. As the crab grows older it increases in size, thus necessitating a change now and then to a larger shell. This habit is not a new one to zoölogists, for undoubtedly it has been observed many times in many parts of the world. While, ordinarily, a hermit occupies a shell of the right size for its body, it sometimes happens that the shell is too small, so that a large part of the anterior portion of the body is exposed; or that the shell is so large that the crab can hardly be seen when it withdraws into the shell.

It seems probable, as Bouvier,[1] Thompson,[2] and Bohn [3] have held, that sometimes the change of shell is brought about spontaneously and at other times because the crab is uncomfortable.

An even more surprising habit which has been reported has to do with the association of hermit crabs with sea anemones. *Eupagurus bernhardus* Linnæus [4] carries on its shell the anemone *Sagartia parasitica* Gosse, while *Eupargus prideauxii* Leach,[5] *Pagurus arrosar* Herbst,[6] and *Paguristes oculatus* Fabricius [7] carry *Adamsia palliata* Bohadsch, *Adamsia rondeletii* Della Chiaje, and *Actinia equina* Linnæus, respectively. Recently [8] *Pagurus deformis* H. Milne-Edwards from the Loyalty Islands and British New Guinea has been described as bearing sea anemones on its shell, and a search through the literature shows that other hermit crabs in a similar condition have been reported; but I shall not list these since their habits do not seem to have been investigated.

The mere occurrence of sea anemones attached to the mollusk shells inhabited by hermit crabs does not close the list of the habits of these interesting animals. It has been reported [9] that when the hermit changes its shell it removes the sea anemones,

[1] Bouvier, E. L., Observations sur les moeurs des pagures faites au laboratoire maritime de Saint-Vaast La-Houghe pendant le mois d'Aout 1891, *Bull. Soc. Philomath. Paris* 4 (1891–1892) 7.

[2] Thompson, M. T., The metamorphosis of the hermit crab, *Proc. Boston Soc. Nat. Hist.* 31 (1903) 193.

[3] Bohn, G., Les animaux marines littoraux, *Bull. l'Instit. Gén. Psychol.* 6 (1903) 625–626.

[4] Smith, Geoffrey, and Weldon, W. F. R., Cambridge Natural History, Crustacea and Arachnids 4 (1909) 172.

[5] Wortley, Stuart, On the habits of Pagurus Prideauxii and Adamsia palliata, *Ann. & Mag. Nat. Hist.* III 12 (1863) 388–390; Brehm's Thierleben 10 (1900) 41; Bronn's Thierreich (Ortmann) 5 (1901) 1254; Keller C., Das Leben des Meers (1895) 71; Calman, W. T., The Life of Crustacea (1911) 213; Agassiz, A., Instinct (?) in hermit crabs, *Ann. & Mag. Nat. Hist.* 17 (1875–1876) 100.

[6] Brunelli, G., Atti. Rend. R. Accad. Lincei. Roma 19 (1910) 77–82.

[7] Brunelli, G., loc. cit.

[8] Borradaille, L. A., On Stomatopoda and Macrura brought by Dr. Willey from the South Sea Islands, Willey Zoölogical Results pt. 4 (1900) 424.

[9] Wortley, Stuart, op. cit.; Gosse, P. H., On the transfer of Adamsia palliata from shell to shell, *The Zoologist* 18 (1859) 6582; Sluiter, C. P., Der Commensalismus zwischen Einsiedlerkrebsen und Actinien, *Kosmos* (1882) 391; Chevreux, M. E., Le Pagurus Prideauxii et ses Commensaur, *Compt. Rend. Assoc. Franc. Avancem. Sci.* (1884); Brehm's Thierleben 10 (1900) 41; Brunelli, G., op. cit.

placing them on the new shell, and that the sea anemones aid the hermit in this procedure.[10]

Some zoölogical text books mention the fact that this transplanting of anemones has been reported; but the subject, if discussed, is generally treated, whether intentionally or not, as though there might be an element of doubt as to the occurrence of this habit. For the reasons mentioned, and because five of my coworkers and I have seen the transfer for the first time in the case of two species of hermits living in Philippine waters, I shall now record my observations.

Along the coast of Mindoro Island, in Port Galera Bay, there occur hermit crabs belonging to two species, *Pagurus deformis* and *Pagurus asper* de Haan, which inhabit mollusk shells of Dolidæ, Strombidæ, *Cassis*, etc. Both of these hermits almost invariably carry two different kinds of sea anemones on their shells; one, a large grayish brown form usually on the sides and another, much smaller, almost colorless form usually on the underside of the mollusk shell below the protruding head of the crab (Plate I). As many as eight of the large anemones and three or four of the smaller kind have been found on a single *Dolium* shell, but so great a number is rather unusual. While in the majority of cases the small anemones are attached on the underside of the mollusk shell below the head of the hermit and the large ones on the upper and lateral surface of the shell, occasionally specimens are found in which the order is reversed.

Either the anemones when in the larval condition attach themselves to the mollusk shell carried by the hermit, or they are placed there by the hermit when they are still very small. On one occasion a beautiful, clean shell which was not beach worn was collected containing a young specimen of *Pagurus deformis*. On the upper surface of this shell were three of the brown anemones, 2, 4, and 8 millimeters across, and just inside the mouth of the shell was one of the colorless species, 3 millimeters in breadth. The extreme smallness of the anemones in this case might indicate that they became attached to the mollusk shells in the larval stage, and this is borne out by the fact that in all our collections at Port Galera we have never found these anemones except on shells inhabited by hermits; but since

[10] Eisig, H., Studien über tiergeographische und verwandte Erscheinungen, I. Zum Verständniss des Commensalismus der Einsiedlerkrebse (Paguriden) und Seeanemonen (Aktinen), *Das Ausland* (1882) 55, 681; Gosse, P. H., op. cit.

the hermits show considerable facility in transferring the anemones, it may be that they detach very young ones from rocks in deep water unexplored by us. On one occasion three young hermits (*Pagurus deformis*) were brought in by collectors, and the shells that they occupied were devoid of anemones.

Wortley [11] has reported that the hermit crab when feeding may transfer pieces of food with its pincers to the sea anemone, but this behavior has not been observed by me nor, so far as I know, by other workers. In fact the accuracy of Wortley's observation has been doubted.[12] Hermits of both of the species of which I collected specimens at Port Galera usually frequent shallow water where there is a rather heavy growth of eel grass which harbors many small organisms. While it does not seem probable that the hermits feed the sea anemones, yet it must be admitted that the anemones are benefited by association with them in that the active, wandering life of the hermit crab presents an ever-changing feeding ground. The small colorless anemones attached at the shell's mouth and located directly under the head of the hermit crab undoubtedly obtain food from the hermit crab, but I have never seen them feeding (Plate I).

It need hardly be pointed out that the sea anemones afford protection for the hermit crab since, in addition to forming a covering which hides the latter, they discharge great numbers of stinging cells when disturbed by an enemy. The crab itself would undoubtedly be a choice morsel for large fishes such as sharks, but it has been pointed out that one mouthful of hermit crabs carrying sea anemones flavored with the piquant stinging cells would satisfy a fish for some time.

As soon as our collectors at Port Galera began to bring in hermits with anemones on their borrowed shells, I was anxious to see if the former would change their shells and transplant the anemones, as had been reported for a few other species in European waters. Accordingly I placed several individuals in an aquarium with a number of clean, empty *Dolium* shells. Nothing of interest happened for some time, but after about two hours one of the hermit crabs became active, took hold of an empty shell, withdrew its abdomen from the shell it was occupying, and inserted its abdomen, almost without examination, into the new shell. In order to have a better chance to observe what might happen, the old shell bearing the anemones and the hermit carrying its new, bare shell were placed in another aquarium. The hermit showed no interest in the anemones

[11] Wortley, S., op. cit. [12] Eisig, H., op. cit.

even after three-quarters of an hour, so after giving the hermit every encouragement such as placing the old shell near it, etc., I came to the conclusion that the species under consideration differs in this respect from the European species. But further observation with other specimens led me to believe that the removal of the hermit from one aquarium to another just after it had vacated the anemone-covered shell disturbed the hermit so much that the usually instinctive behavior in which the anemones are transferred to the new habitation was inhibited.

I shall now describe my observations of a case in which the behavior of *Pagurus deformis* during its change of habitation may be called normal although inaccurate. In this case a hermit, in a shell carrying two large, grayish brown anemones on the upper surface and a small white one in the mouth of the shell, was placed near a *Dolium* shell somewhat larger than the one it was occupying. The hermit began to examine the new shell almost immediately; it put its pincers and some of its legs inside of the shell and remained in this position for a considerable length of time. Occasionally the pincers were moved about and were used apparently to examine the outside of the shell. Then, suddenly, the abdomen was inserted into the new shell, and the hermit without moving away grasped one of the large anemones, clawing, pinching, and pulling it. The anemone, instead of contracting as it would if disturbed by the observer, remained expanded even though the mauling it received was really very strenuous and although it was frequently jammed against the newly occupied shell. After these movements had continued for at least ten minutes the base of the anemone became loose in several places. Instead of completing its work at once, the hermit began to pinch and claw the other large anemone which withdrew its tentacles, soon however protruding them again. Then suddenly the hermit left the second one, and picked off the small white one which it applied at the mouth of the new shell almost directly under its own head, where the small anemone soon became firmly attached. Then the crab again attacked one of the large anemones, removed it easily, turned it round and round between its legs and pincers, and finally pushed the base against the side of the new shell. The anemone failed to become attached, slipped down onto the hermit's legs, stuck to them for a moment, dropped off, and finally attached itself to the glass bottom of the aquarium. Again the hermit crab seemed to lose interest in the anemone upon which it was working, and began tugging, pinching, and scratching the only one remaining attached to its old shell. After a long

period of handling and some little prying up of the edges of the base of the anemone, during which time the tentacles contracted completely, the anemone suddenly slipped off, apparently of its own accord. The hermit then caught the anemone which had just slipped off, rolled it around and around for a few seconds and then, with the aid of the hind legs, applied the tentacle side against the shell. Again the anemone slipped off and was disregarded for a moment while the hermit picked up the other anemone. Still holding the latter it lifted up the one that had just slipped off and rolled them both around for some little time. Finally one became attached to the side of the shell by one edge of the base and was left to shift for itself. The other was passed up on the opposite side of the shell with the aid of the posterior legs of the hermit and soon both anemones became firmly attached with their tentacles beautifully expanded.

Strange as it may appear, the crab never seems to cause any injury, although the base of the anemone is very thin and when taken off by man is easily torn.

While the actions of this hermit crab were not nearly so accurate as those of some others I have observed, yet like all of them it showed a constant and hurried activity which seemed to indicate that some inherited nervous condition existed which was directing its actions. Furthermore, during the time in which this remarkable behavior was taking place the hermit crab, although at other times reacting quickly to movements outside of the aquarium, showed almost no reaction to the stimuli ordinarily produced by people passing or moving in front of the aquarium.

After the hermit had transferred all of the anemones from its old shell it began to work on the anemones of a small shell inhabited by another hermit crab. The latter immediately withdrew into its shell but left the large pincer exposed and open, so that one of the legs of the intruder slipped into the trap and was caught. The hermit, thus held fast, discontinued its attack for a time; in fact, until the captor loosened its hold and allowed the leg to be withdrawn. Instead of leaving, however, the attacking hermit renewed the scratching, pinching, and pulling until it was caught again by the leg. The intruder was held in this way for about a half hour during which it was inactive; but as soon as the leg was released the mauling of the anemones began again. These activities were repeated several times, but as long as I watched the two hermit crabs no anemone was removed.

I have observed other hermit crabs of the species *Pagurus deformis* which were even more inaccurate in their actions than the one we have just considered. In one case a hermit changed to an empty shell, worked on the anemones of the old shell for a few moments, and then took up its habitation again in the old shell. Soon, however, it inserted its abdomen again into the new shell and after about an hour's work succeeded in loosening an anemone. This it lifted upside down to the upper surface in such a manner that it became attached to the apex of the shell merely by one edge of the base where it hung with the tentacles hanging downward. Soon, however, partly as the result of the hermit moving about and turning its shell, the anemone became firmly attached in its normal position with the tentacles directed upward. About an hour later the hermit succeeded in removing another large anemone from its old shell, but instead of setting it on top the hermit placed it in the mouth of the new shell where the smaller species of anemone is usually put. The transfer of the latter (there were two of these) was not seen. Observations on this hermit were discontinued until the next morning when I found that both of the large anemones were in their usual positions on the back of the new shell, the one formerly placed at the mouth either having been transplanted by the hermit during the night or having moved of its own accord to the outside of the shell. One of the small anemones had been removed from the old habitation and apparently an attempt had been made to attach it at the mouth of the shell; but the transfer had been inaccurate, so that the anemone had become attached at the base of the walking legs of the crab near the mouth. The other small anemone was still attached to the old shell.

In the case of the species of hermit crab *Pagurus asper* the transfer of anemones from one shell to another was accomplished in practically the same manner as in the case of *Pagurus deformis*, except that the movements were slower.

My observations on the active and speedy shore crab *Ocypoda arenaria* Catesby [13] and the experiments of Yerkes and Huggins [14] with the crayfish show that, in the case of the former, past experiences leave an impress at least on the nervous system, and that the crayfish is able to solve very simple problems, such as

[13] Cowles, R. P., Habits, reactions, and associations in Ocypoda arenaria, *Papers Tortugas Lab. Carnegie Inst. Washington* 2 (1908) 34.

[14] Yerkes, R. M., and Huggins, G. E., Habit formation in the crawfish Cambarus affinis, *Harvard Psychological Studies* 1 (1903) 565.

finding its way out of a very simple labyrinth with greater and greater accuracy as the number of trials is increased. Such a "mind" is probably possessed by the hermit crab, but it would require a great stretch of imagination to believe that the hermit crab, if it really feeds the anemone, does so with the knowledge that it is caring for an animal which protects it from enemies; or that, when the hermit crab removes the sea anemones from a shell which it has left and plants them on a new home, it knows that they will be of future use; or that, when the anemone allows itself to be pinched and pulled and pried away from a shell by a hermit, it knows that it is in the hands of a friend. We cannot believe that this lowly crustacean, during its lifetime, has learned by experience that its care of the sea anemone is advantageous, although we know that crabs in general do profit by experience. Yet, assuming that the remarkable behavior of the hermit is due to instinct—that is, to an "inherited combination of reflexes" which have been so brought together by the nervous system that the behavior has become fixed and adaptive in the species—it is extremely difficult to conceive how it has acquired these habits.

## ILLUSTRATIONS

### PLATE I

FIG. 1. A hermit crab, *Pagurus deformis* Edw., carrying large and small sea anemones on its shell. Drawn from a preserved specimen from Port Galera, Mindoro. Slightly less than natural size.

2. Hermit crabs, showing large and small sea anemones attached to the shells. From a photograph of living specimens.

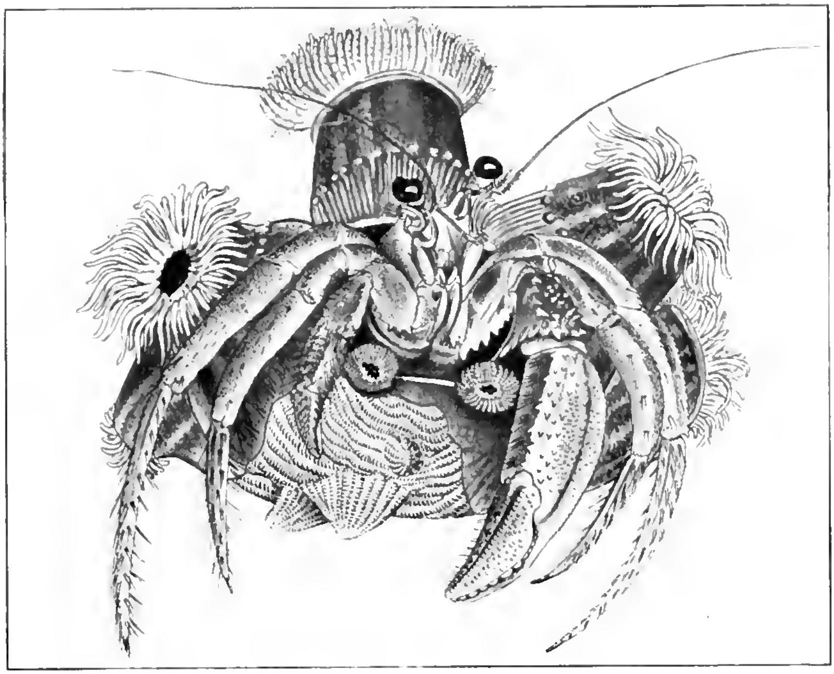


Fig. 1. A hermit crab, carrying large and small sea anemones on its shell.

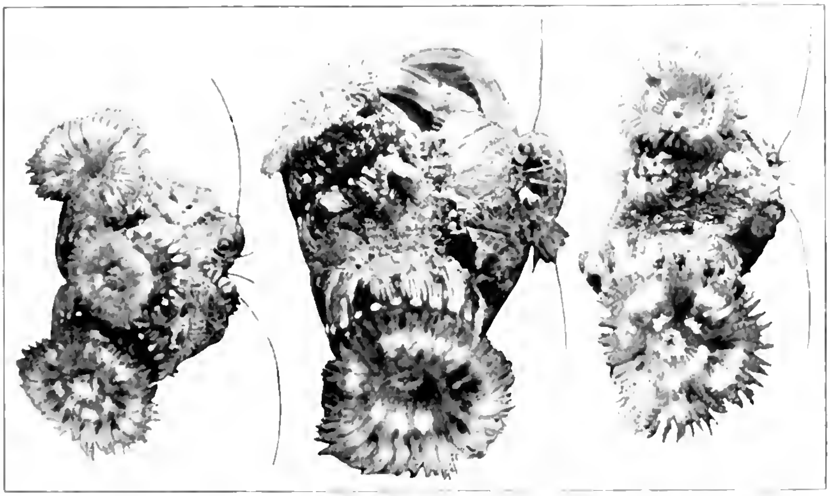


Fig. 2. Hermit orabs with sea anemones attached to the shells.

PLATE I.

# MILK PRODUCED IN SOUTHERN CHINA [1]

By C. O. Levine

*Of Canton Christian College*

ONE PLATE

Through investigations begun in November, 1916, some interesting data have been secured in regard to the milking qualities of native and European cattle in southern China.

Three classes of milk animals have been studied: European cattle, the native water buffalo (known in the Philippine Islands as carabao), and the native, humped cattle. The work has been done chiefly in the vicinities of Canton and Hongkong, the only regions in Kwangtung (which is the southernmost province in China) where dairying has as yet developed into an industry of any extent.

European cows, or foreign cows as the Chinese call them, are the most popular for dairy purposes. In the dairies of Canton and Hongkong, which utilize approximately 1,600 cows, about 1,200 are European. The European cows have been imported from Australia, America, and England, or are the offspring of such imported cows. In the various dairies may be found Shorthorns, Holsteins, Ayrshires, Guernseys, Jerseys, and crosses among these breeds and with the native, humped cows. There are a few pure-bred cows. The Shorthorns, which are the commonest, are chiefly of the white, hornless variety that have been imported from Australia.

European cows are never allowed to graze because of the presence everywhere in the grass of the fever tick. They readily contract fever when exposed to it, and the disease usually proves fatal. However, European cattle born in southern China readily become immune to the fever, as they do in Texas where fever is common. In spite of the greater labor and risk experienced in keeping European cows, they are preferred to the native cows because of the larger amount of milk given and their efficiency, as compared with native cattle, in converting feed into milk.

A good description of the water buffalo (*Bubalus bubalis* Lyd.),

[1] Some of the data contained in this paper have been published in bulletin 17, Canton Christian College, Canton, China.

of southern China, is given by Bailey.[2] The buffalo is principally used for draft purposes. Old animals are slaughtered for beef. In Canton, Hongkong, and other cities of southern China an increasing number is kept for the rich milk produced. There are no special breeds of dairy buffalo in southern China as there are in India. Buffaloes kept for milk are usually mature cows that have been used as draft animals for some time. During the period a cow is milked she is not required to work in that capacity. When milked, and fed grain and good grass, the cows have a long lactation period. It is not uncommon for them to give milk for from eight to twelve or more months. While the amount of milk is very low—usually from 3 to 15 pounds a day (about 1.4 to 6.8 kilograms), with an average of about 4.5 pounds (about 2 kilograms) a day for the lactation period—it is very rich in fat, containing from three to four times as much fat as European cows' milk.

Œstruation in the female buffalo does not occur, as a rule, until the heifer is two years old. It occurs one month after parturition, and reoccurs regularly every twenty-eight to thirty days until the animal again becomes pregnant.

I have secured definite records on the exact length of the gestation period with only two cows; in one case it was three hundred ten days, and in the other, three hundred fourteen.

In order to secure a long lactation period as well as the maximum amount of milk, buffalo cows kept for milk are usually not bred until three or four months after freshening. The cows are considered profitable for dairy purposes until they are about 15 years old.

The Chinese in South China call the native cow *wong ngan*, "yellow cow." This bovine is a variety of the humped species of cattle (*Bos indicus*) common in the Orient. The hump is much less pronounced than it is in most breeds of Indian cattle. In the males the hump is usually 6 to 8 inches high above the shoulders. It is much smaller in the females than in the males. The dewlap is large, but is not developed to the degree common in Indian cattle. In color, these native yellow cattle are similar to the Jerseys. They vary from yellow-red to brown-black. Many are brindle. There are no white, and very few spotted, individuals. The tongue, nostrils, and teats are black. The cream-colored ring above the nostrils in the Jersey is also a characteristic of these cows. Males weigh from 800 to 1,000 pounds (about 362 to 454 kilograms). Mature females weigh

[2] Cyclopedia of American Agriculture 3 (1908–09) 292.

from 600 to 800 pounds (about 272 to 362 kilograms). Their milk is considerably richer in fat than is that of any European breed, though not so rich as is the buffalo milk. The amount of milk given is usually about the same as that given by the buffalo cows, or a little less. They have a full, deep quarter and a deep layer of meat on the loin and back. They are used chiefly for draft and beef purposes. They are gentle, and much easier to handle than are the buffaloes. Very few are milked.

## MILK ANALYSES

In making the fat analyses of milk a Babcock fat-testing outfit was used. The proteins were determined by the Kjeldahl method described by Hawk.[3] The total solids were determined by evaporating a weighed sample of milk on a steam bath until the weight became constant. The ash was determined by heating the evaporated total solids over a gas flame until the weight became constant. The amount of sugar was found by subtracting the sum of the fat, ash, and proteids from the total solids. The percentage of each was found by dividing the weight of the final product by the weight of the sample of milk analyzed.

TABLE I.—*Showing analyses of Canton buffaloes' milk, European cows' milk in Canton, European cows' milk in America, and native, yellow cows' milk.*

[Numbers give percentages.]

| Constituent. | Canton buffalo. | European cow, Canton. | European cow, America. | Yellow cow. |
|---|---|---|---|---|
| Fat | 12.60 | 3.80 | 3.69 | 8.00 |
| Proteins | 6.04 | 3.23 | 3.53 | |
| Sugar | 3.70 | 5.96 | 4.88 | |
| Ash | 0.86 | 0.82 | 0.73 | |
| Water | 76.80 | 86.20 | 87.17 | |
| Total solids | 23.20 | 13.90 | 12.25 | |

All the samples of milk analyzed were taken by me directly from the barn as each cow was milked; not from bottled milk that is sold to the public and is frequently diluted with water.

The analyses show that European cows' milk is practically the same as when produced in the countries from which the cows have come. With more analyses the slight differences in some of the constituents will probably prove to be still less. Sixty duplicate analyses of fat, or one hundred twenty in all, from the

[3] Practical Physiological Chemistry. P. Blakiston's Son & Co., Philadelphia (1916) 483.

milk of twelve cows, extending over a period of eighteen months, were made. Ten analyses were made for each of the remaining constituents.

The analyses of buffalo milk included four hundred duplicate analyses for fat in a herd of fifty buffalo cows kept in the Canton Christian College dairy, including both individual and herd tests, and herd tests of five dairies in Canton. Compound analyses of both morning and afternoon milk were also made. The average was found to be 12.60 per cent fat. The lowest test was 9.80 per cent. The lowest average for a lactation period of all the cows was 9.65 per cent. The highest average was 15.60 per cent. The percentages of constituents in the buffalo milk other than fat represent averages of ten analyses. The protein varied from 5.60 to 6.10, with an average of 6.04 per cent. Sugar was low, varying from 3.51 to 3.75, with an average of 3.70 per cent. The average for ash was 0.86, varying from 0.71 to 0.99 per cent. The total solids averaged 23.20, varying from 21.00 to 25.20 per cent.

Tables II and III give the analyses of milk for fat, and Tables IV to XVII the production records of buffalo cows for which we have records extending over a period of several months, or for entire lactation periods. The analyses for butter fat were made twice a month. The milk for twenty-four hours was weighed twice a month. The average of the two analyses was taken as the average for the month, and the average amount of milk at the two weighings was taken as the average daily production for the month. The cows were all in the Canton

TABLE II.—*Complete analyses of buffalo milk.*

[The samples analyzed were composite samples taken from twelve cows in the college dairy in November, 1917. The milking in the morning was begun at 4 o'clock, and in the afternoon, at 2 o'clock. Numbers give percentages.]

| Sample No. | Time. | Fat. | Ash. | Protein. | Sugar. | Total solids. | Water. |
|---|---|---|---|---|---|---|---|
| 1 | a. m. | 11.00 | 0.94 | 6.04 | 4.00 | 22.98 | 77.02 |
| 2 | p. m. | 12.80 | 0.90 | 6.10 | 3.57 | 23.37 | 76.63 |
| 3 | do | 13.00 | 0.71 | 5.71 | 3.32 | 23.02 | 76.98 |
| 4 | do | 13.63 | 0.74 | 5.94 | 3.57 | 22.88 | 77.08 |
| 5 | do | 12.10 | 0.90 | 6.14 | 3.83 | 22.87 | 77.04 |
| 6 | do | 14.00 | 0.92 | 6.42 | 3.87 | 25.21 | 74.79 |
| 7 | a. m. | 11.50 | 0.95 | 5.80 | 3.70 | 22.95 | 77.05 |
| 8 | do | 12.00 | 0.94 | 6.00 | 3.60 | 22.54 | 77.45 |
| 9 | do | 12.34 | 1.01 | 6.28 | 3.71 | 23.37 | 76.63 |
| 10 | do | 12.20 | 0.77 | 5.90 | 4.23 | 23.02 | 76.98 |
| Averages | | 12.46 | 0.88 | 6.04 | 3.70 | 23.08 | 76.92 |

Christian College dairy at the time that the tests and the records were made.

The grain fed consisted of a ration made up of 2 pounds wheat bran and 1 pound rice chop. Each of the cows was fed about 1 pound of this mixed feed a day for each pound of milk given. The chop was fed cooked, and the bran was added to the rice after the rice was cooked. This feed was fed separately

TABLE III.—*Complete analyses of European cows' milk. Analyses made during January and February, 1917.*

[Numbers give percentages.]

| Sample No.[a] | Fat. | Ash. | Protein. | Sugar. | Total solids. | Water. |
|---|---|---|---|---|---|---|
| 1 | 3.20 | 0.745 | 3.18 | 6.47 | 13.70 | 86.30 |
| 2 | 3.50 | 0.840 | 3.20 | 5.28 | 13.[illegible]2 | 86.18 |
| 3 | 4.50 | 0.736 | 3.24 | 5.18 | 14.65 | 85.35 |
| 4 | 4.60 | 0.900 | 4.10 | 5.20 | 13.80 | 86.20 |
| 5 | 3.80 | 0.780 | 3.25 | 5.54 | 13.37 | 86.63 |
| 6 | 4.44 | 0.800 | 3.10 | 5.60 | 13.94 | 86.06 |
| 7 | 3.50 | 0.880 | 3.80 | 6.00 | 13.97 | 86.03 |
| 8 | 4.10 | 0.888 | 3.40 | 5.63 | 14.12 | 85.88 |
| 9 | 5.20 | 0.740 | 3.20 | 5.30 | 14.41 | 85.56 |
| 10 | 4.00 | 0.800 | 3.05 | 6.10 | 13.95 | 86.05 |
| Averages | 3.96 | 0.820 | 3.23 | 5.96 | 13.90 | 86.21 |

[a] Samples 1 and 2 are of milk from the Hongkong Dairy Farm Co., in Victoria, Hongkong. The samples are from bottled milk from a herd of from 500 to 700 European cows, most of which are Holsteins. Samples 3, 4, 5, 6, and 7 are from the mixed milk of the Sinkee Dairy, in Canton. In this dairy 90 to 100 foreign cows are kept, Guernseys and Shorthorns predominating. Samples 8, 9, and 10 are from the mixed milk of four cows in the Canton Christian College dairy. These four cows are of mixed breeding with Shorthorn blood predominating.

TABLE IV.—*Milk produced by buffalo cow 1. Average fat for six months, 12.23 per cent.*

[Freshened in August, 1916. Lactation period ended June 30, 1917. Records began January 1, 1917.]

| Month. | Morning. | | Afternoon. | | For 24 hours. | | Average fat. | Total for month. | |
|---|---|---|---|---|---|---|---|---|---|
| | Milk. | Fat. | Milk. | Fat. | Milk. | Fat. | | Milk. | Fat. |
| | *lbs.* | *P. ct.* | *lbs.* | *P. ct.* | *lbs.* | *lbs.* | *P. ct.* | *lbs.* | *lbs.* |
| January | 2.20 | 10.24 | 2.00 | 12.00 | 4.20 | 0.434 | 11.5 | 130.2 | 14.97 |
| February | 2.00 | 10.20 | 2.30 | 12.90 | 4.30 | 0.503 | 11.9 | 120.4 | 12.82 |
| March | 1.50 | 11.20 | 1.30 | 13.50 | 2.80 | 0.316 | 13.3 | 84.0 | 11.21 |
| April | 2.00 | 12.50 | 1.50 | 13.50 | 3.50 | 0.450 | 13.0 | 105.0 | 13.65 |
| May | 1.70 | 12.50 | 1.20 | 14.50 | 2.90 | 0.386 | 12.6 | 89.9 | 11.95 |
| June | 0.50 | 12.00 | 0.25 | 14.00 | 0.75 | 0.100 | 13.3 | 22.50 | 2.99 |
| Totals for six months | | | | | | | | 552.0 | 67.59 |

to each cow twice a day. About 0.75 ounce of salt was mixed with the grain at each feeding. About 40 pounds of water were added to the grain at each feeding, making a very wet feed, the cows drinking it. This is the usual method of feeding grain to cattle in southern China. The cows were fed four times a day all they could consume of a mixture of green grasses, cut along the canal dikes or from the college campus. The amount of grass eaten daily by each cow varied from 40 to 60 pounds.

The milk of the native yellow cow is rich in fat, averaging about 8 per cent. No analysis has been made of this milk for constituents other than fat.

TABLE V.—*Milk produced by buffalo cow 2. Average fat for lactation period, 11.80 per cent.*

[Freshened January 28, 1917. Lactation period ended September 30, 1917.]

| Month. | Morning. | | Afternoon. | | For 24 hours. | | Average fat. | Total for month. | |
|---|---|---|---|---|---|---|---|---|---|
| | Milk. | Fat. | Milk. | Fat. | Milk. | Fat. | | Milk. | Fat. |
| | *lbs.* | *P. ct.* | *lbs.* | *P. ct.* | *lbs.* | *lbs.* | *P. ct.* | *lbs.* | *lbs.* |
| February | 2.7 | 8.8 | 2.3 | 13.8 | 5.0 | 0.541 | 10.9 | 140 | 15.26 |
| March | 2.7 | 9.0 | 1.1 | 13.0 | 4.0 | 0.474 | 10.1 | 124 | 13.64 |
| April | 3.3 | 10.0 | 2.8 | 15.1 | 6.1 | 0.753 | 12.2 | 183 | 22.57 |
| May | 2.0 | 9.0 | 1.9 | 13.1 | 4.1 | 0.447 | 10.8 | 127 | 13.72 |
| June | 2.75 | 9.00 | 2.25 | 13.5 | 5.0 | 0.451 | 9.0 | 150 | 13.50 |
| July | 2.5 | 10.5 | 2.2 | 12.6 | 4.7 | 0.539 | 11.5 | 148 | 16.75 |
| August | 2.0 | 11.0 | 1.5 | 14.2 | 3.5 | 0.432 | 12.2 | 109 | 13.45 |
| September | 1.8 | 11.6 | 1.2 | 14.4 | 3.0 | 0.372 | 12.4 | 90 | 11.16 |
| Totals for eight months | | | | | | | | 1,071 | 120.05 |

TABLE VI.—*Milk produced by buffalo cow 3. Average fat for six months, 12.95 per cent.*

[Freshened October 20, 1916. Lactation period ended June 28, 1917. Records began January 1, 1917.]

| Month. | Morning. | | Afternoon. | | For 24 hours. | | Average fat. | Total for month. | |
|---|---|---|---|---|---|---|---|---|---|
| | Milk. | Fat. | Milk. | Fat. | Milk. | Fat. | | Milk. | Fat. |
| | *lbs.* | *P. ct.* | *lbs.* | *P. ct.* | *lbs.* | *lbs.* | *P. ct.* | *lbs.* | *lbs.* |
| January | 2.0 | 11.8 | 2.7 | 13.8 | 4.7 | 0.606 | 12.8 | 145.7 | 17.45 |
| February | 2.3 | 12.0 | 1.5 | 14.0 | 3.8 | 0.486 | 12.6 | 106.4 | 13.40 |
| March | 2.3 | 13.2 | 1.1 | 15.4 | 3.4 | 0.473 | 14.0 | 105.4 | 14.76 |
| April | 2.1 | 12.2 | 1.2 | 14.2 | 3.3 | 0.436 | 13.3 | 99.0 | 13.16 |
| May | 1.9 | 13.5 | 1.3 | 14.5 | 3.2 | 0.444 | 13.90 | 99.2 | 13.79 |
| June | 1.9 | 12.2 | 0.75 | 13.0 | 2.65 | 0.322 | 12.2 | 79.5 | 9.70 |
| Totals for six months | | | | | | | | 635.2 | 82.26 |

In all regions where buffalo milk has been analyzed it has been found to contain a great deal more fat than does European cows' milk. However, in no region from which the analysis of milk has been reported does the buffalo milk contain as much fat as in southern China.

A breed of buffaloes known as the Delhi buffalo (known in the Philippine Islands as the ram's horn buffalo) from North Central India has been introduced into Hongkong. This is an excellent breed for dairy purposes, because of the amount and quality of milk given. According to Hongkong authorities the milk contains about the same amount of fat as does the native Chinese buffalo milk. One of these Delhi buffalo dairies at

TABLE VII.—*Milk produced by buffalo cow 4. Average fat for lactation period, 12.63 per cent.*

[Freshened January 2, 1917. Lactation period ended November 30, 1917.]

| Month. | Morning. | | Afternoon. | | For 24 hours. | | Average fat. | Total for month. | |
|---|---|---|---|---|---|---|---|---|---|
| | Milk. | Fat. | Milk. | Fat. | Milk. | Fat. | | Milk. | Fat. |
| | *lbs.* | *P. ct.* | *lbs.* | *P. ct.* | *lbs.* | *lbs.* | *P. ct.* | *lbs.* | *lbs.* |
| January | 2.4 | 11.2 | 2.2 | 14.2 | 4.6 | 0.581 | 12.6 | 133.4 | 16.80 |
| February | 2.8 | 12.0 | 2.0 | 15.6 | 4.8 | 0.648 | 13.3 | 134.4 | 17.87 |
| March | 3.2 | 11.8 | 2.4 | 14.1 | 5.6 | 0.715 | 12.8 | 173.6 | 22.22 |
| April | 2.5 | 11.0 | 2.1 | 14.5 | 4.6 | 0.579 | 12.6 | 138.0 | 17.39 |
| May | 2.4 | 11.4 | 2.0 | 14.8 | 4.4 | 0.570 | 12.4 | 132.0 | 16.38 |
| June | 2.2 | 11.0 | 1.8 | 15.0 | 4.0 | 0.514 | 12.8 | 120.0 | 15.16 |
| July | 2.2 | 12.5 | 1.3 | 16.0 | 3.5 | 0.438 | 13.8 | 108.0 | 14.90 |
| August | 1.9 | 10.1 | 1.1 | 13.0 | 3.0 | 0.335 | 11.0 | 93.0 | 10.23 |
| September | 2.3 | 11.0 | 1.5 | 14.8 | 3.8 | 0.475 | 12.5 | 114.0 | 14.25 |
| October | 2.6 | 11.5 | 1.2 | 15.3 | 3.8 | 0.483 | 12.4 | 114.0 | 14.11 |
| November | 1.5 | 10.2 | 1.0 | 12.5 | 2.4 | 0.278 | 11.1 | 72.0 | 8.00 |
| Totals for eleven months | | | | | | | | 1,332.4 | 167.31 |

TABLE VIII.—*Milk produced by buffalo cow 5. Average fat for five months, 13.12 per cent.*

[Freshened August 10, 1916. Lactation period ended June 30, 1917. Records begun January, 1917.]

| Month. | Morning. | | Afternoon. | | For 24 hours. | | Average fat. | Total for month. | |
|---|---|---|---|---|---|---|---|---|---|
| | Milk. | Fat. | Milk. | Fat. | Milk. | Fat. | | Milk. | Fat. |
| | *lbs.* | *P. ct.* | *lbs.* | *P. ct.* | *lbs.* | *lbs.* | *P. ct.* | *lbs.* | *lbs.* |
| January | 2.7 | 11.25 | 2.0 | 12.70 | 4.7 | 0.557 | 11.87 | 145.7 | 17.29 |
| February | 2.3 | 12.50 | 2.0 | 13.80 | 4.3 | 0.494 | 11.54 | 120.0 | 13.68 |
| March | 2.3 | 13.50 | 1.1 | 15.50 | 3.4 | 0.481 | 14.15 | 105.4 | 15.31 |
| April | 2.0 | 14.00 | 1.5 | 15.00 | 3.5 | 0.505 | 14.40 | 105.0 | 15.12 |
| May | 1.9 | 13.90 | 1.3 | 15.10 | 3.2 | 0.460 | 14.30 | 99.2 | 14.18 |
| Totals for five months | | | | | | | | 575.3 | 75.58 |

TABLE IX.—*Milk produced by buffalo cow 6. Average fat for six months, 12.34 per cent.*

[Freshened August 2, 1916. Lactation period ended June 24, 1917. Records began January 1, 1917.]

| Month. | Morning. | | Afternoon. | | For 24 hours. | | Average fat. | Total for month. | |
|---|---|---|---|---|---|---|---|---|---|
| | Milk. | Fat. | Milk. | Fat. | Milk. | Fat. | | Milk. | Fat. |
| | *lbs.* | *P. ct.* | *lbs.* | *P. ct.* | *lbs.* | *lbs.* | *P. ct.* | *lbs.* | *lbs.* |
| January | 2.2 | 9.0 | 1.7 | 12.9 | 3.9 | 0.414 | 10.6 | 120.9 | 12.81 |
| February | 2.4 | 10.0 | 1.7 | 14.1 | 4.1 | 0.480 | 11.7 | 114.8 | 13.41 |
| March | 1.9 | 13.0 | 1.4 | 16.3 | 3.3 | 0.435 | 13.2 | 102.1 | 13.47 |
| April | 2.0 | 10.5 | 1.4 | 13.9 | 3.4 | 0.425 | 11.9 | 102.0 | 12.14 |
| May | 1.2 | 12.00 | 0.9 | 12.5 | 2.1 | 0.268 | 12.88 | 63.1 | 8.42 |
| June | 1.2 | 10.2 | 1.2 | 12.6 | 2.4 | 0.282 | 11.69 | 72.0 | 8.41 |
| Totals for six months | | | | | | | | 574.9 | 68.66 |

TABLE X.—*Milk produced by buffalo cow 7. Average fat for five months, 13.82 per cent.*

[Freshened July 4, 1916. Lactation period ended May 31, 1917. Records began January 1, 1917.]

| Month. | Morning. | | Afternoon. | | For 24 hours. | | Average fat. | Total for month. | |
|---|---|---|---|---|---|---|---|---|---|
| | Milk. | Fat. | Milk. | Fat. | Milk. | Fat. | | Milk. | Fat. |
| | *lbs.* | *P. ct.* | *lbs.* | *P. ct.* | *lbs.* | *lbs.* | *P. ct.* | *lbs.* | *lbs.* |
| January | 2.2 | 12.2 | 1.2 | 13.6 | 3.4 | 0.432 | 12.84 | 92.0 | 11.81 |
| February | 1.7 | 12.0 | 1.5 | 15.2 | 3.2 | 0.432 | 13.2 | 89.6 | 11.83 |
| March | 1.3 | 12.0 | 2.0 | 16.3 | 3.2 | 0.464 | 14.1 | 118.0 | 16.64 |
| April | 1.8 | 13.1 | 2.1 | 16.0 | 3.9 | 0.441 | 14.7 | 107.0 | 15.73 |
| May | 0.6 | 16.0 | | | 0.6 | 0.096 | 16.0 | 18.6 | 2.87 |
| Totals for five months | | | | | | | | 425.2 | 58.88 |

TABLE XI.—*Milk produced by buffalo cow 8. Average butter fat for five months, 15.48 per cent.*

[Freshened May 2, 1916. Lactation period ended May 31, 1917. Records began January 1, 1917.]

| Month. | Morning. | | Afternoon. | | For 24 hours. | | Average fat. | Total for month. | |
|---|---|---|---|---|---|---|---|---|---|
| | Milk. | Fat. | Milk. | Fat. | Milk. | Fat. | | Milk. | Fat. |
| | *lbs.* | *P. ct.* | *lbs.* | *P. ct.* | *lbs.* | *lbs.* | *P. ct.* | *lbs.* | *lbs.* |
| January | 1.5 | 14.0 | 1.7 | 17.2 | 3.2 | 0.481 | 15.0 | 99.2 | 14.8 |
| February | 1.8 | 14.6 | 1.0 | 17.4 | 2.8 | 0.437 | 15.6 | 76.4 | 11.92 |
| March | 1.4 | 14.4 | 0.8 | 17.6 | 2.2 | 0.333 | 15.1 | 68.2 | 10.30 |
| April | 1.1 | 15.0 | 0.7 | 16.7 | 1.8 | 0.227 | 15.4 | 54.0 | 8.32 |
| May | 1.1 | 16.5 | 1.0 | 17.6 | 2.1 | 0.347 | 16.5 | 65.1 | 10.74 |
| Totals for five months | | | | | | | | 362.9 | 66.08 |

Kowloon, Hongkong, had thirty cows that were giving from 10 to 20 pounds of milk a day on dry rice straw and very little rice and bran, when visited by me in January, 1919. When

given succulent feed they give from 30 to 50 pounds of milk a day. These cows have a lactation period of from eight to twelve months. How well the flow of milk is kept up throughout the lactation period is not known.

Buffalo milk is pure white, with absolutely no tint of yellow. Cream and butter made from it are rather oily and have but a faint tint of yellow. By mixing European cows' cream with the buffalo cream and using vegetable butter color the color and the texture can be greatly improved.

TABLE XII.—*Milk produced by buffalo cow 51. Average fat for lactation period, 9.65 per cent.*

[Freshened July 4, 1918. Lactation period ended May 31, 1919. Records began immediately after freshening.]

| Month. | Morning. | | Afternoon. | | For 24 hours. | | Average fat. | Total for month. | |
|---|---|---|---|---|---|---|---|---|---|
| | Milk. | Fat | Milk. | Fat. | Milk. | Fat. | | Milk. | Fat. |
| | *lbs.* | *P. ct.* | *lbs.* | *P. ct.* | *lbs.* | *lbs.* | *P. ct.* | *lbs.* | *lbs.* |
| July | 6.2 | 8.5 | 5.0 | 9.5 | 11.2 | 1.002 | 8.9 | [illegible] | 22.67 |
| August | 6.8 | 8.5 | 4.8 | 10.0 | 11.6 | 1.058 | 9.12 | 359.6 | 32.77 |
| September | 6.6 | 8.8 | 5.2 | 10.4 | 11.8 | 1.121 | 9.50 | 354.0 | 32.63 |
| October | 6.0 | 9.50 | 4.2 | 10.0 | 10.2 | 0.990 | 9.70 | [illegible] | [illegible] |
| November | 5.6 | 10.02 | 3.6 | 11.0 | 9.6 | 0.957 | 9.96 | 228.0 | 22.71 |
| December | 5.2 | 9.50 | 3.0 | 11.2 | 8.2 | 0.830 | 10.12 | 250.0 | 25.32 |
| January | 4.8 | 9.30 | 3.0 | 11.5 | 7.8 | 0.701 | 10.14 | 242.0 | 24.52 |
| February | 4.5 | 9.60 | 3.0 | 11.0 | 7.5 | 0.762 | 10.16 | 210.0 | 21.33 |
| March | 3.5 | 10.25 | 3.0 | 10.0 | 6.5 | 0.660 | 10.24 | 201.0 | 20.44 |
| April | 3.4 | 9.20 | 2.8 | 11.2 | 6.2 | 0.627 | 10.12 | 180.0 | [illegible] |
| May | 4.5 | 10.00 | | | 4.5 | 0.450 | 10.00 | 134.0 | 6.18 |
| Totals for eleven months | | | | | | | | 2,672.0 | 257.46 |

TABLE XIII.—*Milk produced by buffalo cow 53. Average fat for seven months, 10.51 per cent.*

[Freshened October 26, 1918. Lactation period not finished.]

| Month | Morning. | | Afternoon. | | For 24 hours. | | Average fat. | Total for month. | |
|---|---|---|---|---|---|---|---|---|---|
| | Milk. | Fat. | Milk. | Fat. | Milk. | Fat. | | Milk. | Fat |
| | *lbs.* | *P. ct.* | *lbs.* | *P. ct.* | *lbs.* | *lbs.* | *P. ct.* | *lbs.* | *lbs.* |
| November | 5.8 | 9.75 | 4.3 | 11.6 | 10.1 | 1.064 | 10.05 | 318.0 | 34.95 |
| December | 5.6 | 9.40 | 4.2 | 12.0 | 9.8 | 1.030 | 10.51 | 303.8 | [illegible] |
| January | 5.0 | 9.20 | 3.8 | 12.5 | 8.8 | 0.985 | 11.27 | 273.8 | 30.74 |
| February | 4.7 | 10.60 | 3.2 | 12.6 | 7.9 | 0.901 | 11.40 | [illegible] | 25.22 |
| March | 4.5 | 10.25 | 2.8 | 11.0 | 7.3 | 0.769 | 10.53 | [illegible] | [illegible] |
| April | 4.0 | 10.00 | 2.5 | 11.2 | 6.5 | 0.680 | 10.46 | [illegible] | 20.40 |
| May | 3.0 | 9.75 | 2.6 | 11.0 | 6.4 | 0.625 | [illegible] | [illegible] | [illegible] |
| Totals for seven months | | | | | | | | 1,756.1 | 185.40 |

Like most milk, buffalo milk has little or no odor. The strong odor often found associated with it is due to foreign substances, such as hair or flakes of dead skin, that fall into the milk when proper sanitary precautions are not used in milking. When such foreign substances get into the milk, the bacteria that they introduce multiply very rapidly and produce gases with unpleasant odors.

In the College dairy both European and buffalo cows are kept. Buffalo milk is much preferred, because of its richness, by both foreigners (American and European) and Chinese. In

TABLE XIV.—*Milk produced by buffalo cow 54. Average fat for nine months, 12.13 per cent.*

[Freshened September 20, 1918. Lactation period not finished.]

| Month. | Morning. | | Afternoon. | | For 24 hours. | | Average fat. | Total for month. | |
|---|---|---|---|---|---|---|---|---|---|
| | Milk. | Fat. | Milk. | Fat. | Milk. | Fat. | | Milk. | Fat. |
| | *lbs.* | *P. ct.* | *lbs.* | *P. ct.* | *lbs.* | *lbs.* | *P. ct.* | *lbs.* | *lbs.* |
| September | 6.2 | 10.0 | 4.6 | 11.5 | 10.8 | 1.199 | 11.11 | 97.2 | 10.79 |
| October | 6.5 | 10.4 | 4.8 | 11.4 | 11.3 | 1.223 | 10.83 | 339.0 | 36.71 |
| November | 6.1 | 10.2 | 5.0 | 11.6 | 11.1 | 1.177 | 11.61 | 333.0 | 38.66 |
| December | 5.5 | 11.0 | 4.0 | 12.5 | 9.5 | 1.105 | 11.63 | 284.5 | 33.09 |
| January | 5.4 | 11.3 | 3.8 | 13.0 | 9.2 | 1.088 | 11.82 | 285.2 | 33.70 |
| February | 5.0 | 11.0 | 3.4 | 13.5 | 8.4 | 1.009 | 12.00 | 235.2 | 27.22 |
| March | 4.5 | 10.7 | 3.7 | 14.8 | 8.2 | 1.029 | 12.44 | 254.2 | 31.62 |
| April | 4.4 | 11.8 | 2.7 | 12.0 | 7.1 | 0.843 | 11.89 | 213.0 | 25.22 |
| May | 3.0 | 13.0 | 3.5 | 13.0 | 6.5 | 0.825 | 13.00 | 201.0 | 26.16 |
| Totals for nine months | | | | | | | | 2,242.3 | 263.10 |

TABLE XV.—*Milk produced by buffalo cow 55. Average fat for lactation period, 11.86 per cent.*

[Freshened September 20, 1916. Lactation period finished May 31, 1919.]

| Month | Morning. | | Afternoon. | | For 24 hours. | | Average fat. | Total for month. | |
|---|---|---|---|---|---|---|---|---|---|
| | Milk. | Fat. | Milk. | Fat. | Milk. | Fat. | | Milk. | Fat. |
| | *lbs.* | *P. ct.* | *lbs.* | *P. ct.* | *lbs.* | *lbs.* | *P. ct.* | *lbs.* | *lbs.* |
| September | 6.3 | 10.0 | 4.0 | 12.3 | 10.3 | 1.122 | 10.89 | 103.0 | 11.22 |
| October | 5.8 | 9.8 | 4.2 | 12.5 | 10.0 | 1.093 | 10.88 | 300.0 | 30.00 |
| November | 5.3 | 10.2 | 4.0 | 13.0 | 9.3 | 1.060 | 11.40 | 279.0 | 31.80 |
| December | 5.0 | 11.5 | 3.8 | 13.5 | 8.8 | 1.090 | 12.38 | 273.8 | 33.87 |
| January | 4.6 | 11.0 | 3.5 | 13.8 | 8.1 | 0.988 | 12.20 | 251.0 | 30.62 |
| February | 4.5 | 11.4 | 3.0 | 14.0 | 7.5 | 0.933 | 12.44 | 210.0 | 26.34 |
| March | 3.3 | 11.0 | 2.5 | 14.60 | 5.8 | 0.728 | 12.54 | 160.0 | 20.06 |
| April | 3.6 | 11.5 | 2.0 | 14.5 | 5.6 | 0.704 | 12.60 | 168.0 | 21.17 |
| May | 2.0 | 13.0 | 1.5 | 14.75 | 3.5 | 0.482 | 13.40 | 108.5 | 14.53 |
| Totals for lactation period | | | | | | | | 1,863.3 | 219.61 |

modifying milk for infants requiring modified milk, the college physicians prefer buffalo milk to European cows' milk because of the ease with which it lends itself to modification. The usual formula for modification is 100 grams of buffalo milk, 18 grams of sugar, and enough boiled or distilled water to make 300 grams. This makes the percentages of fat, proteins, sugar, and ash about right for infants, as when thus modified the milk compares well with human milk. For children of 3 years or more the milk is usually simply thinned by adding an equal amount of water.

### FEED FOR DAIRY COWS

The commonest concentrates fed are equal proportions of a cheap grade of rice chop and wheat bran, fed twice a day. Native cattle are grazed on the public grave and hill land during the daytime. Green grass is cut daily for the European cows, which are kept stabled all day. Most of the grass is cut from

TABLE XVI.—*Milk produced by buffalo cow 60. Average fat for six months, 11.20 per cent.*

[Freshened December 1, 1918. Lactation period not finished.]

| Month. | Morning. | | Afternoon. | | For 24 hours. | | Average fat. | Total for month. | |
|---|---|---|---|---|---|---|---|---|---|
| | Milk. | Fat. | Milk. | Fat. | Milk. | Fat. | | Milk. | Fat. |
| | *lbs.* | *P. ct.* | *lbs.* | *P. ct.* | *lbs.* | *lbs.* | *P. ct.* | *lbs.* | *lbs.* |
| December | 6.2 | 9.50 | 4.2 | 11.75 | 10.4 | 1.381 | 11.55 | 322.4 | 36.59 |
| January | 6.0 | 10.20 | 4.0 | 12.00 | 10.0 | 1.092 | 10.92 | 310.0 | 33.85 |
| February | 5.8 | 10.50 | 4.0 | 12.40 | 9.8 | 1.105 | 11.27 | 271.1 | 30.90 |
| March | 4.8 | 9.25 | 3.0 | 13.00 | 7.8 | 0.934 | 11.97 | 242.8 | 28.74 |
| April | 4.0 | 9.50 | 2.0 | 11.50 | 6.0 | 0.610 | 10.16 | 180.0 | 18.19 |
| May | 3.5 | 10.00 | 3.0 | 10.00 | 6.5 | 0.650 | 10.00 | 201.5 | 20.15 |
| Totals for six months | | | | | | | | 1,531.1 | 168.42 |

TABLE XVII.—*Milk produced by buffalo cow 63. Average fat for six months, 10.38 per cent.*

[Freshened December 10, 1918. Lactation period not finished.]

| Month. | Morning. | | Afternoon. | | For 24 hours. | | Average fat. | Total for month. | |
|---|---|---|---|---|---|---|---|---|---|
| | Milk. | Fat. | Milk. | Fat. | Milk. | Fat. | | Milk. | Fat. |
| | *lbs.* | *P. ct.* | *lbs.* | *P. ct.* | *lbs.* | *lbs.* | *P. ct.* | *lbs.* | *lbs.* |
| December | 5.0 | 9.8 | 4.6 | 11.2 | 9.6 | 0.965 | 10.05 | 201.6 | 19.35 |
| January | 5.8 | 9.6 | 4.3 | 11.4 | 10.1 | 1.046 | 10.45 | 313.0 | 32.71 |
| February | 6.0 | 9.7 | 4.2 | 11.6 | 10.2 | 1.069 | 10.48 | 285.6 | 28.97 |
| March | 5.5 | 9.8 | 4.5 | 11.25 | 10.0 | 1.045 | 10.45 | 310.0 | 31.39 |
| April | 4.8 | 10.0 | [illegible] | 11.5 | 8.9 | 0.940 | 10.56 | 267.0 | 28.19 |
| May | 5.5 | 10.75 | 3.0 | 12.0 | 8.5 | 1.059 | 11.26 | 263.5 | 29.65 |
| Totals for six months | | | | | | | | [illegible] | [illegible] |

TABLE XVIII.—*Analyses of buffalo milk produced in southern China compared with that produced in other countries.*

[Numbers give percentages.]

| | Southern China. | India.[a] | Philippine Islands.[b] | Italy.[a] |
|---|---|---|---|---|
| Fat | 12.60 | 7.95 | 6.84 | 7.99 |
| Protein | 6.04 | 4.00 | 4.97 | 4.13 |
| Sugar | 3.70 | 5.18 | 5.16 | 4.75 |
| Ash | 0.86 | 0.78 | 0.83 | 0.97 |
| Water | 76.80 | 82.09 | 82.20 | 82.16 |

[a] Bailey's Cyclopedia of American Agriculture 3 (1908) 295.

[b] Philippine Agriculturalist and Forester 6 (1917) 110.

NOTE.—Attention may be called to the results recorded by Dovey, Philip. Journ. Sci., § A 8 (1913) 153–155, showing the constituents of nineteen "authentic samples of pure carabao's milk." Only two of these show less than 7 per cent fat while four show more than 12.60 per cent.—EDITORS.

the canal banks. Some of the more progressive dairies are beginning to grow guinea grass, which does very well on the hillsides in this region. When well fertilized with manure from the barns this grass produces a crop from 18 to 24 inches high every two to three weeks throughout the rainy season, from April to September. Dry rice straw is also fed.

## COMMON DISEASES

Rinderpest and tick fever are the principal diseases to which cattle are subject. Prof. C. W. Howard, of the biology department of Canton Christian College, says that the latter is caused by the same organism (*Piroplasma bigeminum*) and transmitted by the same tick (*Boophilus annulatus*) as in the Southern States of the United States. Both the buffalo and the native yellow cow are largely immune to the fever, while the European cows quickly succumb to the disease when exposed to it. However, European calves born here readily become immune. Rinderpest causes heavy losses, especially among buffaloes and European cattle, during the months of March and April. The Hongkong Dairy Farm has had outbreaks of rinderpest among European cattle every year for the past five or six years. The use of rinderpest serum has checked the disease in every outbreak. It is interesting to note that the Chinese dairies have suffered very little from rinderpest in their herds of European cattle, although in most cases their methods of caring for the cows are not very sanitary.

According to Dr. C. M. Heanley, of the Hongkong Vaccine and Bacteriology Laboratory, tuberculosis is practically unknown

among the native cattle of southern China, occurring once in 250,000 head and then only when the animals are closely stabled with European cattle. Dr. A. Gibson, colonial veterinarian, Victoria, Hongkong, tells me that he has seen but two cases of tuberculosis among native cattle, during the thirteen years that he has held his present position. These two cases were in bullocks. He has never seen tuberculosis in the Chinese water buffalo.

My measurements of twelve buffalo cows, in the college dairy, May 20, 1919, are given in Table XIX. These twelve cows are typical of the buffalo in southern China.

TABLE XIX.—*Measurements of twelve buffalo cows, in the Canton Christian College dairy.*

[Numbers give centimeters.]

| Cow No. | Length. | | Height. | | | Chest girth. | Body. | | Loin; width. |
|---|---|---|---|---|---|---|---|---|---|
| | Tip of nose to buttocks. | Top of shoulders to hips. | At withers. | At croup. | At lowest point of back. | | Girth at navel. | Depth at navel. | |
| 51 | 223.0 | 75.0 | 120.0 | 124.5 | 117.0 | 221.0 | 249.0 | 77.5 | 38.0 |
| 52 | 225.0 | 87.0 | 122.0 | 124.0 | 119.0 | 205.0 | 249.0 | 79.0 | 41.0 |
| 53 | 218.0 | 73.0 | 120.0 | 120.0 | 116.0 | 193.0 | 237.0 | 74.5 | 39.0 |
| 54 | 226.0 | 85.0 | 125.0 | 130.0 | 122.0 | 205.0 | 236.0 | 84.0 | 36.5 |
| 55 | 228.0 | 70.0 | 125.0 | 125.5 | 121.0 | 209.0 | 248.5 | 76.5 | 38.0 |
| 56 | 214.0 | 70.0 | 120.0 | 117.5 | 113.5 | 194.0 | 227.7 | 66.5 | 32.0 |
| 57 | 244.0 | 81.0 | 225.5 | 124.0 | 122.0 | 204.5 | 255.5 | 77.0 | 40.0 |
| 58 | 236.0 | 79.0 | 121.5 | 120.0 | 118.0 | 199.5 | 237.2 | 68.0 | 38.0 |
| 59 | 230.0 | 76.5 | 117.0 | 117.0 | 114.0 | 189.0 | 226.0 | 71.0 | 33.5 |
| 60 | 229.0 | 80.0 | 120.0 | 117.5 | 131.2 | 191.0 | 245.0 | 72.0 | 37.5 |
| 61 | 240.0 | 80.0 | 124.5 | 128.0 | 121.0 | 206.4 | 245.0 | 80.0 | 37.5 |
| 62 | 270.0 | 79.0 | 126.5 | 122.0 | 124.0 | 202.0 | 245.0 | 85.0 | 38.0 |

| Cow No. | Hips; width. | Under-line; length. | Chest between legs; width. | Length of head; top of poll to end of nose. | Face; width at eyes. | Muzzle; width. | Horns. | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Length, outside curve. | Diameter at base. | Spread, widest point. |
| 51 | 52.0 | 76.0 | 27.0 | 49.0 | 22.0 | 20.0 | 54.0 | 12.0 | 66.5 |
| 52 | 54.5 | 77.0 | 25.0 | 46.0 | 22.0 | 21.0 | 60.0 | 11.0 | 60.0 |
| 53 | 56.0 | 82.5 | 21.0 | 55.5 | 22.0 | 20.5 | 62.0 | 8.5 | 69.0 |
| 54 | 53.2 | 74.0 | 23.0 | 50.0 | 20.7 | 17.8 | 48.2 | 8.5 | 53.8 |
| 55 | 56.0 | 70.0 | 24.0 | 49.0 | 21.0 | 16.5 | 53.3 | 7.8 | 68.0 |
| 56 | 49.0 | 76.0 | 22.0 | 46.0 | 22.5 | 16.5 | 56.5 | 8.0 | 56.5 |
| 57 | 57.0 | 85.0 | 26.6 | 50.5 | 21.2 | 18.0 | 52.0 | 8.5 | 58.2 |
| 58 | 51.0 | 85.0 | 23.5 | 48.0 | 20.5 | 19.5 | 54.5 | 7.6 | 64.5 |
| 59 | 52.0 | 76.0 | 22.0 | 47.5 | 20.5 | 17.0 | 59.0 | 9.5 | 53.5 |
| 60 | 52.0 | 76.5 | 25.5 | 49.5 | 22.2 | 16.0 | 65.1 | 8.5 | 51.0 |
| 61 | 68.5 | 66.0 | 24.0 | 50.0 | 23.0 | 13.0 | 64.6 | 9.5 | 53.0 |
| 62 | 54.0 | 73.0 | 29.0 | 50.0 | 22.0 | 16.0 | 52.0 | 9.0 | 72.5 |

TABLE XIX.—*Measurements of twelve buffalo cows, in the Canton Christian College dairy*—Continued.

| Cow No. | Distance between tips of horns. | Neck, from back of poll to top of shoulders. | Neck; throat to front of sternum. | Upper arm; point of shoulder to center of elbow. | Lower arm; elbow to center of knee. | Lower thigh; center of stifle to center of hock. | Fore-shank; center of knee to center of pastern. | Rear shank; center of knee to center of pastern joint. | Width of— Fore-hoof. | Width of— Rear hoof. |
|---|---|---|---|---|---|---|---|---|---|---|
| 51 | 62.0 | 62.0 | 42.0 | 33.0 | 40.0 | 41.0 | 18.0 | 35.0 | 11.0 | 12.0 |
| 52 | 51.0 | 64.0 | 40.0 | 35.0 | 37.0 | 40.0 | 18.5 | 30.0 | 13.5 | 12.5 |
| 53 | 63.5 | 58.5 | 45.5 | 36.0 | 38.0 | 39.0 | 21.5 | 26.0 | 13.0 | 13.0 |
| 54 | 54.6 | 64.0 | 42.5 | 36.4 | 37.0 | 42.0 | 20.3 | 35.0 | 13.2 | 11.0 |
| 55 | 53.5 | 79.0 | 49.5 | 35.0 | 33.0 | 40.5 | 19.0 | 33.0 | 14.5 | 12.0 |
| 56 | 19.8 | 55.5 | 45.5 | 33.0 | 30.5 | 30.8 | 19.3 | 31.0 | 13.8 | 12.0 |
| 57 | 20.5 | 77.0 | 42.0 | 27.0 | 34.0 | 43.0 | 20.1 | 33.0 | 14.0 | 12.0 |
| 58 | 62.0 | 61.0 | 38.5 | 28.0 | 34.0 | 37.5 | 21.0 | 30.5 | 13.5 | 12.0 |
| 59 | 83.5 | 59.5 | 48.5 | 35.0 | 34.5 | 30.5 | 18.5 | 32.5 | 14.0 | 11.5 |
| 60 | 36.0 | 64.0 | 44.0 | 37.0 | 34.0 | 38.0 | 20.0 | 31.6 | 13.0 | 12.0 |
| 61 | 45.0 | 72.5 | 42.0 | 36.0 | 34.6 | 43.0 | 21.5 | 33.0 | 11.5 | 12.0 |
| 62 | 72.5 | 62.0 | 54.0 | 40.0 | 38.0 | 43.0 | 23.0 | 36.0 | 12.6 | 11.4 |

| Cow No. | Length of— Fore-hoof. | Length of— Rear hoof. | Circumference of— Knee. | Circumference of— Hoof. | Circumference of— Fore-shank. | Circumference of— Rear shank. | Circumference of— Fore-pastern. | Circumference of— Rear pastern. | Distance from— Fore-legs to floor of chest. | Distance from— Hind legs to flank. |
|---|---|---|---|---|---|---|---|---|---|---|
| 51 | 14.0 | 14.0 | 31.0 | 45.0 | 21.5 | 23.9 | 27.0 | 26.5 | 48.0 | 63.0 |
| 52 | 16.0 | 14.0 | 32.0 | 42.0 | 22.0 | 22.5 | 28.5 | 28.0 | 51.0 | 60.5 |
| 53 | 15.0 | 14.0 | 31.5 | 42.5 | 22.0 | 23.6 | 26.2 | 26.8 | 48.0 | 60.5 |
| 54 | 15.4 | 13.0 | 31.5 | 42.0 | 21.0 | 21.6 | 27.2 | 25.8 | 48.0 | 62.0 |
| 55 | 15.2 | 14.0 | 31.2 | 40.5 | 20.5 | 20.3 | 27.5 | 26.5 | 58.0 | 61.7 |
| 56 | 14.0 | 13.0 | 30.0 | 37.5 | 20.0 | 20.5 | 25.5 | 23.5 | 45.5 | 55.4 |
| 57 | 15.0 | 13.0 | 32.5 | 43.6 | 21.8 | 21.5 | 31.5 | 29.0 | 52.0 | 65.5 |
| 58 | 14.0 | 13.2 | 33.0 | 42.5 | 20.5 | 21.1 | 27.10 | 27.4 | 44.5 | 59.0 |
| 59 | 13.5 | 12.4 | 30.0 | 38.5 | 19.5 | 21.0 | 26.8 | 29.0 | 40.7 | 56.2 |
| 60 | 14.0 | 12.0 | 33.0 | 42.5 | 23.0 | 22.0 | 28.0 | 27.7 | 53.3 | 59.5 |
| 61 | 16.0 | 15.0 | 34.0 | 37.0 | 21.5 | 22.7 | 28.2 | 28.0 | 48.0 | 63.0 |
| 62 | 16.0 | 15.0 | 34.1 | 40.0 | 22.1 | 29.5 | 29.5 | 26.9 | 53.0 | 67.0 |

# ILLUSTRATIONS

PLATE I

FIG. 1. Native yellow cattle of China, grazing on the cemetery hills north of Canton, China.

2. Water buffaloes, in Canton Christian College dairy.

3. Water buffaloes, in Canton Christian College dairy.

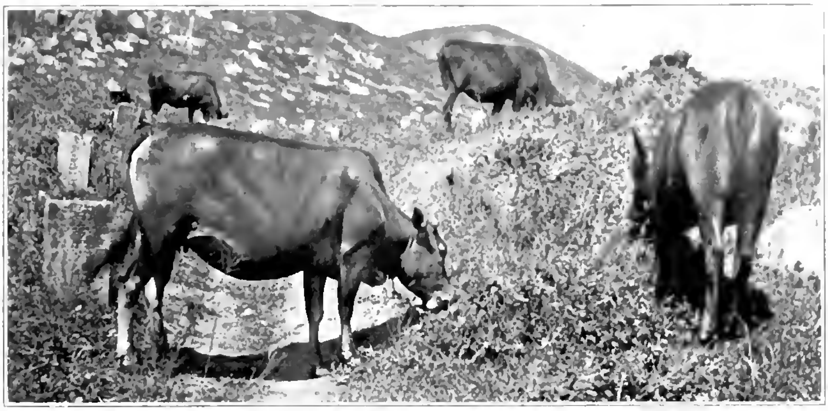


Fig. 1. Native yellow cattle of China.

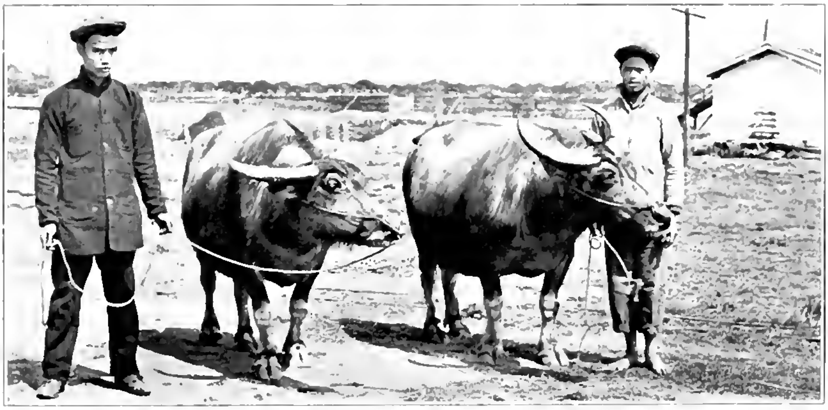


Fig. 2. Water buffaloes.

Fig. 3. Water buffaloes.

PLATE I.

# THE ANALYSIS OF PORTLAND CEMENT RAW MIXTURE[1]

By J. C. Witt

*Chemist, Bureau of Science, Manila*

TWO TEXT FIGURES

Analyses of a cement raw mixture by several methods failed to give conformatory results. Each of these methods was studied with the object of increasing the accuracy, lessening the time required, and discovering the sources of error. Little has been written on the analysis of raw mixtures, and still less concerning the sources of error, especially when indirect methods for determining the calcium carbonate content are followed. Though the mixture here discussed doubtless presents more analytical difficulties than the average, work with it has pointed out several factors that affect the results obtained with this class of materials.

When a cement plant is past the experimental stage and is in regular operation, complete analyses of the raw materials or of the raw mixture are, as a rule, required only occasionally. The proportioning of the mixture is usually based on the percentage of calcium carbonate, which is the most important constituent. This determination must be made repeatedly; its frequency at a given plant depending on a number of factors, such as the character of the raw materials, the arrangement of the machinery, and the like. As with other manufacturing processes, it is desirable to find a method of analysis that will give results within the required limits of accuracy, in the shortest time. The methods available may be divided into two classes; namely, those in which the calcium itself is determined and those in which some other constituent is determined. They include the following:

1. By determining calcium and calculating to calcium carbonate.
    - By precipitation with ammonium oxalate.
        - Drying or ignition of precipitate and weighing.
        - Solution of precipitate in acid and titration.
        - Precipitation without complete removal of silica.
        - Precipitation in presence of an organic acid.
    - Other methods for the determination of calcium.

[1] Received for publication May 26, 1919.

2. By determining some other constituent and calculating to calcium carbonate.
   - By evolution of carbon dioxide.
     - Absorption in soda lime or alkali hydroxide solution.
     - Loss in weight due to evolution of gas from Geissler's or similar apparatus.
     - Loss on ignition.
     - Hydrometer apparatus.
     - Monometer apparatus.
     - Calcimeter.
   - By titration methods.
   - By determining acid-insoluble material.

*Determination of calcium by precipitation as calcium oxalate.*—Most of the methods depend on the fact that calcium may be precipitated from solutions of its salts by the addition of ammonium oxalate. The solution may be titrated directly with standard oxalate solution,[2] or an excess of oxalate may be added, the precipitate collected and the amount remaining uncombined with the excess oxalate titrated with potassium permanganate.[3] Calcium oxalate may be dried and weighed;[4] may be ignited to the oxide,[5] carbonate,[6] or sulphate;[7] or may be dissolved in sulphuric[8] or in hydrochloric acid,[9] and titrated with potassium permanganate. It may be also determined by the Fox[10] photometric method.[11]

*Determination of calcium without the use of ammonium oxalate.*—The methods include precipitation as the iodate,[12] the tungstate,[13] the arsenate,[14] and the carbonate.[15] According to Knobloch,[16] calcium may be determined by adding ferric chloride and zinc iodide solutions, and titrating the iodine liberated with

[2] Prunier, Journ. Chem. Soc. 48 A2 (1885) 296.

[3] Kraut, Chem. Centralbl. 1 (1856) 316.

[4] Fresenius, C. R., Quantitative Chemical Analysis. New York, John Wiley and Sons 1 (1904) 272.

[5] Fritzshe, Zeitschr. f. Anal. Chem. 3 (1864) 179.

[6] Fresenius, op. cit. 273.

[7] Fresenius, op. cit. 272.

[8] Mohr, Titrirmethode, ed. 7, 239.

[9] Peters, C. A., Am. Journ. Sci. 12 (1901) 216.

[10] Hines, J. I. D., Journ. Am. Chem. Soc. 22 (1900) 269.

[11] For other comments on methods involving the use of ammonium oxalate, see Young, R. F., and Baker, B. F., Chem. News 86 (1902) 148, and Pagireff, W., Journ. Chem. Soc., 82 A2 (1902) 356.

[12] Sonstadt, E., Chem. News 29 (1874) 209.

[13] Saint-Sernin, A., Compt. Rend. 156 (1913) 1019.

[14] Fox, P. J., Journ. Ind. Eng. Chem. 5 (1913) 910.

[15] Forte, O., Journ. Chem. Soc. 66 A2 (1894) 322.

[16] Knobloch, J., Journ. Chem. Soc. 68 A2 (1895) 326.

sodium thiosulphate. A neutral solution of a calcium salt may be titrated with standard sodium carbonate solution.[17]

*Determination of constituents other than calcium.*—Since the calcium in a cement mixture is usually largely present as the carbonate, the carbon dioxide evolved on ignition, or on treating with acid, is often made the basis for determining the calcium carbonate content. The following are among the many methods that may be used:

The gas may be absorbed in soda lime or in an alkali hydroxide solution,[18] and the resulting mixture either weighed or titrated with standard acid. The weight of the carbon dioxide evolved may be found by the use of any one of a number of apparatus such as Geissler's,[19] or by weighing the sample before and after ignition.[20] Barker [21] has designed a special form of hydrometer in which the sample is placed and treated with hydrochloric acid. The decrease in weight due to the evolution of carbon dioxide is shown by the position of the apparatus in the water in which it floats. Chapin [22] calculates the volume of the evolved gas from the increase in pressure in a closed vessel, as indicated by a monometer. The volume of evolved gas is frequently measured in a gas burette, or some type of calcimeter [23] is employed.

A method of a different type consists in treating the sample with standard acid and, when the reaction is complete, titrating the excess acid with standard alkali. The details of this method differ in various laboratories.[24] In some cases the calcium carbonate content may be estimated from the acid-insoluble matter.[25]

The United States Government official method for the determination of calcium in raw mixtures specifies that the sample be ignited over a blast lamp for fifteen minutes and then treated with hydrochloric acid.[26] The silica is dehydrated and filtered

[17] Vizern, Journ. Chem. Soc. 66 A2 (1894) 161.

[18] Fresenius, C. R., Zeitschr. f. Anal. Chem. 2 (1863) 49, 341.

[19] Journ. f. Prak. Chem. 60 (1853) 35.

[20] Treadwell and Hall, Analytical Chemistry. New York, John Wiley and Sons 2 (1907) 292.

[21] Barker, J. F., Journ. Ind. Eng. Chem. 9 (1917) 786.

[22] Chapin, W. H., Journ. Ind. Eng. Chem. 10 (1918) 527.

[23] For description of the Scheibler-Dietrich calcimeter see George Lunge, Technical Methods of Chemical Analysis. New York, D. van Nostrand Co. 1 (1908) 659.

[24] Kluge, F., Chem. Zeitg. 20 (1896) 372; Meade, R. K., Portland Cement. The Chemical Publishing Co., Easton, Pa. (1911) 313.

[25] Meade, op. cit. 326.

[26] If anything remains undecomposed it is separated, fused with sodium carbonate, dissolved, and added to the original solution.

out. The iron and the aluminium are removed by precipitating twice with ammonium hydroxide. The determination is completed as follows:[27]

To the combined filtrate from the $Al_2O_3 + Fe_2O_3$ precipitate a few drops of $NH_4OH$ are added, and the solution brought to boiling. To the boiling solution 20 cc of a saturated solution of ammonium oxalate is added, and the boiling continued until the precipitated $CaC_2O_4$ assumes a well-defined granular form. It is then allowed to stand for 20 minutes, or until the precipitate has settled, and then filtered and washed. The precipitate and filter are placed wet in a platinum crucible, and the paper is burned off over a small flame of a Bunsen burner. It is then ignited, redissolved in HCl, and the solution made up to 100 cc with water. Ammonia is added in slight excess, and the liquid is boiled. If a small amount of $Al_2O_3$ separates this is filtered out, weighed, and the amount added to that found in the first determination, when greater accuracy is desired. The lime is then reprecipitated by ammonium oxalate, allowed to stand until settled, filtered and washed,[28] weighed as oxide after ignition and blasted in a covered crucible to constant weight, or determined with dilute standard permanganate.[29]

Although the procedure given the preference in the official method (igniting the precipitate and weighing the oxide) is subject to several sources of error, such as the solubility of the oxalate in water,[30] the possible contamination of the precipitate,[31] the absorption of moisture during weighing, and the like, it is generally conceded to be the most accurate method known at present. Its principal disadvantage in commercial work is the time required. According to the original report, it takes almost seven hours to run a sample of raw mixture to the completion of the calcium determination, and the time required to obtain the result can be only slightly shortened by omitting the completion of the silica, iron, and aluminium determinations. Only a few minutes for each sample may be saved by substituting the titration method, if all the separations are made as specified.

In connection with the titration method, however, several modifications have been developed which shorten the time, though

[27] From Method suggested for the analysis of limestones, raw mixtures, and Portland cement by the committee on uniformity in technical analysis with the advice of W. F. Hillebrand, *Cir. U. S. Bur. Standards* 33 (1912) 15. For the original report of this committee, see Journ. Soc. Chem. Ind. 21 (1902) 12–30.

[28] The volume of wash water should not be too large; vide Hillebrand. *United States Geological Survey. Bull. 422, p. 119.* [Footnote in original.]

[29] The accuracy of this method admits of criticism, but its convenience and rapidity demand its insertion. [Footnote in original.]

[30] See also Peters, C. A., loc. cit.

[31] Täubner, H., Chem. Zeitg. 26 (1902) 246.

they have some effect on the accuracy of the results. One such modification is to precipitate and reprecipitate the iron and aluminium from hydrochloric acid solution without first removing the silica. The calcium in the filtrate is precipitated once as the oxalate, and the precipitate is titrated with permanganate.[32]

The method may be still further shortened by neutralizing the original hydrochloric acid solution with ammonia and adding some organic acid in which calcium oxalate is not appreciably soluble. The calcium may be precipitated as oxalate without the removal of iron and aluminium. The calcium oxalate is filtered out, and the determination is completed in the regular manner. Citric,[33] tartaric,[34] and oxalic[35] acid have been used.

Of the methods noted above, several are used extensively for controlling the calcium carbonate content of raw mixtures in cement plants. These include some modification of the determination of calcium by precipitation with ammonium oxalate and titration with permanganate, the determination of carbon dioxide with the calcimeter, the determination of total alkalinity by titration with standard acid and alkali, and the determination of acid-insoluble matter. The last named is used much less frequently than the others. The procedure in each case that I have found best suited to the raw mixture discussed in this paper is as follows:

In determining the calcium, the usual method of igniting the raw mixture before adding hydrochloric acid at the beginning of an analysis is not sufficient.[36] Results are the same either with or without ignition, but almost 2 per cent too low. It is necessary to fuse with sodium carbonate. To avoid one filtration, the whole sample is fused instead of simply the acid-insoluble residue. The melt is dissolved in hydrochloric acid and the iron and the aluminium are removed by twice precipitating with ammonia. The calcium in the filtrate is precipitated once with ammonium oxalate, and the precipitate is dissolved in dilute sulphuric acid and titrated with permanganate. The titration method has been found more satisfactory than ignition, for use

[32] Enright, B., Journ. Am. Chem. Soc. 26 (1904) 1003.

[33] Passon, Max, Zeitschr. f. Ang. Chem. (1898) 776.

[34] Blum, L., Zeitschr. f. Anal. Chem. 39 (1900) 152.

[35] Meade, R. K., Chem. Eng. 1 (1904) 21.

[36] With reference to igniting the sample, W. F. Hillebrand, Journ. Soc. Chem. Ind. 21 (1902) 25, says: "Whether all cement mixtures can be thus rendered wholly soluble I am unable to say, but doubtless most of them can be, and if so, this method should always be resorted to in order to avoid the use of alkali carbonates."

in the Tropics. The high humidity of the atmosphere renders it difficult to weigh calcium oxide in an ordinary platinum crucible without absorption of moisture. Results obtained with the method just described have been found to compare favorably with those of the official method; consequently it was adopted as standard for the present work.

In making a calcimeter determination, the sample is treated with hydrochloric acid (density, 1.125), and the calcium carbonate content is calculated from the volume of carbon dioxide evolved. In some laboratories the amount of sample taken is not kept constant, but tables are used which indicate the weight that corresponds to the observed temperature and pressure. When this amount is placed in the appparatus, no reduction of the observed volume to standard conditions is necessary. However, this arrangement has certain disadvantages when used in routine work. The continual changing of weights becomes tiresome and the average routine analyst is likely to make mistakes, especially at night. Also, if for any reason it is desired to make a number of determinations at one time, the samples cannot all be weighed at once because the temperature or the pressure may change before the work has been completed and thus render the results incorrect. Also, if the apparatus was standardized at a given temperature and pressure with Iceland spar, the result could not be applied to a determination made after these conditions had changed without giving rise to error.

The method used in connection with this work has proved more satisfactory. A standard raw mixture is prepared, having as nearly as possible the ideal composition of the regular mixture. This is prepared in quantities sufficient to last for a month or two and is analyzed in triplicate for calcium by the potassium permanganate titration method. At the beginning of his day's work the analyst records the temperature and pressure, weighs out an equal amount of the standard and of his first sample to be tested, and places them successively in the calcimeter. As long as the temperature and the pressure remain the same, it is not necessary to use another portion of the standard; but, if either changes, a new standard must be weighed and analyzed with the next routine sample. If during the course of the day they both return to former values, the result of the standard at that temperature and pressure may be used.

Since with each determination conditions are the same for both standard and sample, the calcium carbonate content of the

sample may be directly calculated from the known content of the standard by proportion. A table for making these calculations covering the usual range of results for both the standard and the sample may be easily prepared. Errors, such as those due to absorption of carbon dioxide in the hydrochloric acid, lack of accuracy in either thermometer or barometer, and the like, are thus automatically corrected. Everything considered, the labor required by this procedure is no greater than that required by the other, and the results are more satisfactory. When the sample contains considerably more silicate than the standard there will be an error in the result, the reason for which is explained in this paper. It has been proposed to correct this by preparing a series of standards ranging from the lowest to the highest calcium content likely to be found in a sample, and then, for a given determination, using the standard nearest that sample in composition. This would be an improvement, but it is doubtful if the increased labor would be justified.

In the acid–alkali titration method, the sample is placed in a 300-cubic centimeter Erlenmeyer flask, fitted with a rubber stopper bearing a vertical glass tube as a condenser. A measured amount of 0.4 *N* hydrochloric acid is added, and brought just to a boil over a Bunsen burner. The solution is cooled, diluted to from 100 to 150 cubic centimeters, and titrated with standard sodium hydroxide of the same concentration, using methyl orange as the indicator. Of the several concentrations of acid tried, 0.4 *N* was the lowest that would dissolve nearly all the sample without the application of heat. However, that solution was not quite complete without warming. Methyl orange is preferred to phenolphthalein, although the end point is more difficult to see. It is not necessary to remove the carbonates in preparing the standard sodium hydroxide solution (as should be done if phenolphthalein is to be used), and it is not necessary to boil the acid after the sample is dissolved, to remove the carbon dioxide.

The method for determining acid-insoluble matter is the same as the one given by Meade, except that hydrochloric acid having a density of 1.125 is used. The sample is treated with this acid, and the mixture is boiled several minutes. The insoluble matter is then collected, washed, ignited, and weighed.

The raw mixture with which this paper is concerned is made from three materials; namely, a hard limestone, and two siliceous materials that are designated silicate 1 and silicate 2. The analyses of these materials are shown in Table I.

TABLE I.—*Analyses of raw materials.*

[Numbers give percentages.]

| | Limestone. | Silicate. 1. | Silicate. 2. |
|---|---|---|---|
| Loss on ignition | 42.86 | 5.77 | 3.24 |
| Silica ($SiO_2$) | 0.68 | 53.76 | 61.35 |
| Iron oxide ($Fe_2O_3$) | 0.30 | 6.84 | 4.82 |
| Aluminium oxide ($Al_2O_3$) | 0.34 | 22.88 | 18.46 |
| Calcium oxide (CaO) | 54.72 | 5.41 | 5.22 |
| Magnesium oxide (MgO) | 0.56 | 1.88 | 2.72 |
| Sodium oxide ($Na_2O$) | 0.60 | 1.65 | 2.26 |
| Potassium oxide ($K_2O$) | trace | 1.84 | 1.95 |
| Sulphuric anhydride ($SO_3$) | trace | trace | trace |

On analyzing a number of samples by the four methods mentioned above and calculating all results to percentage calcium carbonate, the agreement was not satisfactory. The analyses of ten samples are shown in Table II. Most of these were prepared in the laboratory from samples of the raw materials, dried and ground to pass a 200-mesh sieve. These are only a few of many comparative analyses that have been made from time to time.

TABLE II.—*The analyses of raw mix by several methods.*

[Numbers give percentages.]

| Sample No. | By titration with potassium permanganate. Total calcium is calculated to calcium carbonate. | By calcimeter. Total carbon dioxide is calculated to calcium carbonate. | By acid-alkali titration. Total alkalinity is calculated to calcium carbonate. | Matter insoluble in hydrochloric acid with density of 1.125. |
|---|---|---|---|---|
| 1 | 54.40 | 51.25 | 53.03 | 22.30 |
| 2 | 62.30 | 59.42 | 61.31 | 17.25 |
| 3 | 66.50 | 64.00 | 65.35 | 16.10 |
| 4 | 76.80 | 76.00 | 76.26 | 11.20 |
| 5 | 77.80 | 77.25 | 76.30 | 21.68 |
| 6 | 78.00 | 77.00 | 76.30 | 21.82 |
| 7 | 79.60 | 78.63 | 78.88 | 11.04 |
| 8 | 83.00 | 83.08 | 81.71 | 8.10 |
| 9 | 84.40 | 84.17 | 83.22 | 7.00 |
| 10 | 86.50 | 86.00 | 85.14 | 6.70 |

## CAUSES OF ERROR

In any analytical procedure certain errors of the process itself—such as inexact calibration of apparatus, slight solubility of precipitates, difficulty of complete washing, and the like—can-

not be eliminated. There is another class of errors due to the composition of the substances under investigation; errors of this class have been found to be largely responsible for the non-concordant results of Table II.

In the first column, the calcium is determined, and the results are calculated to calcium carbonate. In the case of the calcimeter or with any other method in which the carbon dioxide is determined, the result in terms of calcium carbonate must be calculated from the total carbon dioxide found. This, of course, assumes that all calcium is present as carbonate and that all carbon dioxide is combined with calcium, which in this case is not true. Carbonates other than calcium are present in small amount in the limestone, causing the results to be slightly too high. However, the calcium in the two siliceous materials is not present as carbonate and consequently is not included when the determination by calcimeter is made. The net result is that the values obtained are low.

In the acid–alkali titration method, the alkalinity or acid-consuming power is calculated to calcium carbonate. In this case the errors due to apparatus and to manipulation may be made very small. However, there are much greater errors due to the composition of the mixture. On being treated with standard acid, all carbonates go into solution and are calculated to calcium carbonate. Of the calcium in the siliceous materials, a portion goes into solution without neutralizing acid equivalent to that which would be required for calcium carbonate, and a portion is undissolved by the acid. Some of the iron and the aluminium in these materials go into solution and consequently neutralize the acid, thereby tending to produce a higher result.[37]

The results obtained by determining the acid-insoluble matter were so irregular that no further analyses by that method were made.

Slight errors are caused by the presence of moisture in the raw mixture as it comes from the tube mill. It has not been found practicable to eliminate these in the routine work. The moisture content of the material as it enters the tube mill is determined at regular intervals and is kept as low as possible

[37] S. B. Newberry, Cem. and Eng. News, March (1903) 35, describes a double titration method by which correction for magnesium may be made. With the raw mixture under investigation, however, the error due to the effect of iron and aluminium cannot be corrected. The error due to magnesium is not corrected because it tends to compensate the other one.

under the prevailing conditions at the plant. It is not practical to dry each sample before analysis, because the results cannot be obtained as rapidly as they are needed. The limestone as it comes from the quarry is frequently contaminated to a greater or less extent with clay different in composition and in analytical behavior from the two siliceous materials regularly used in making the mix. The results obtained by testing the three raw materials by the calcimeter and the alkali-acid titration method are shown in Table III.

TABLE III.—*Partial analyses of the three raw materials by different methods.*

| Calcium carbonate. | Limestone. | Silicate. 1. | Silicate. 2. |
|---|---|---|---|
| | *Per cent.* | *Per cent.* | *Per cent.* |
| By calcimeter (total $CO_2$ calculated to $CaCO_3$) | 94.50 | 0.00 | 0.00 |
| By titration (total acid neutralized calculated to $CaCO_3$) | 95.40 | 2.60 | 3.30 |

It will be noted that although the two silicates contain considerable calcium there is no evolution of gas when they are treated with acid. However, although they contain no carbonates, they have acid-consuming values equivalent to 2.60 per cent and 3.30 per cent calcium carbonate, respectively. The portion of each, soluble in 0.4 *N* hydrochloric acid, gives the results shown in Table IV, calculated to the basis of the original sample.

TABLE IV.—*Constituents of the two silicates.*

| | Silicate. 1. | Silicate. 2. |
|---|---|---|
| | *Per cent.* | *Per cent.* |
| Iron and aluminium oxides | 2.57 | 6.65 |
| Calcium oxide (calculated to $CaCO_3$) | 2.26 | 3.08 |

The sources of error with the analytical methods employed and their effect on the results are illustrated in fig. 1. This is based on the typical analysis shown in Table V.

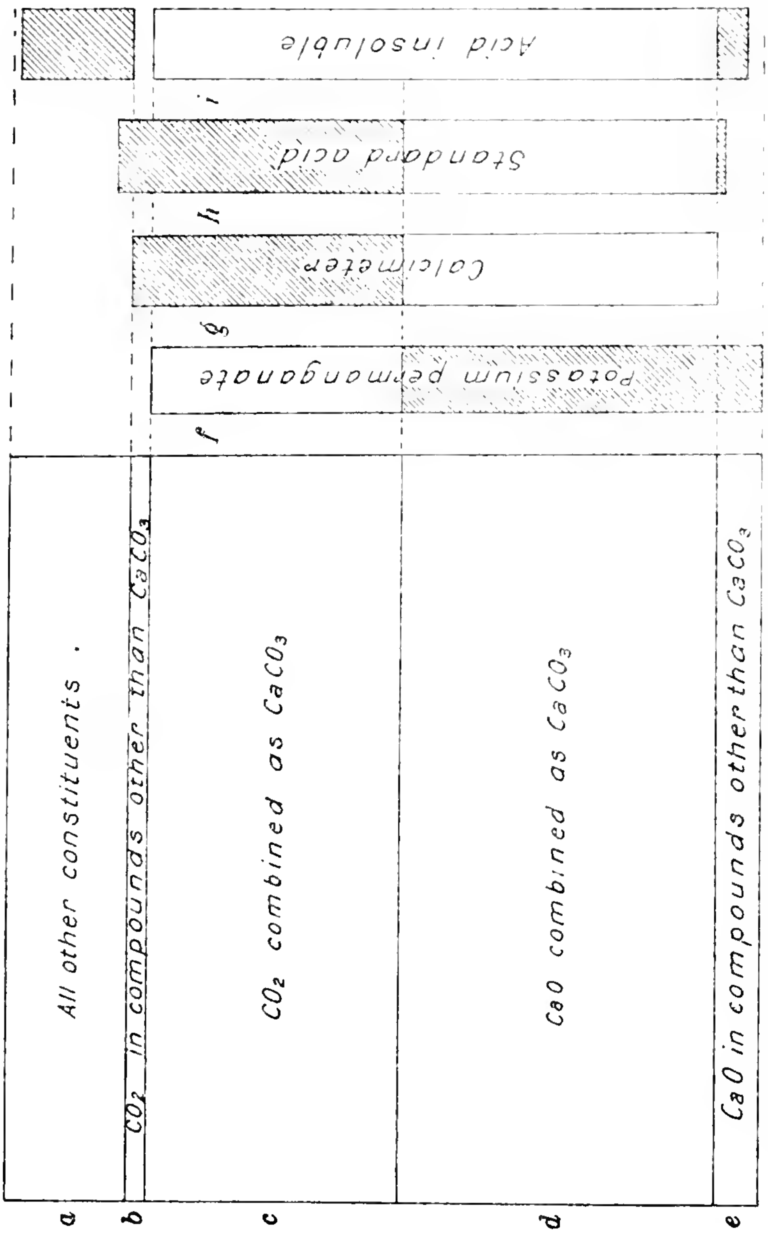



FIG. 1. Showing composition of raw mixture and some causes for nonagreement of results by several methods. Areas *c* and *d* are drawn to scale, but *b* and *e* are exaggerated by 5 for the sake of clearness, thereby making *a* proportionately smaller.

TABLE V.—*Typical analysis.*

| Constituent. | | Equivalent to calcium carbonate. |
|---|---|---|
| | *Per cent.* | *Per cent.* |
| Calcium oxide combined as calcium carbonate | 42.08 | 75.05 |
| Calcium oxide in other compounds | 1.23 | 2.19 |
| Carbon dioxide combined as calcium carbonate | 32.99 | 75.05 |
| Carbon dioxide in other compounds | 0.46 | 1.37 |
| All other constituents | 23.24 | |
| Acid-soluble portions of silicate | | 0.65 |

The square represents the composition of a sample of raw mixture having the analysis given in Table V. The calcium oxide combined as calcium carbonate and the carbon dioxide combined as calcium carbonate are drawn to scale. The calcium oxide and the carbon dioxide in compounds other than calcium carbonate are exaggerated five times to make them more easily seen on the diagram, and the rectangle representing all other constituents is made proportionally smaller. The rectangles *f*, *g*, *h*, and *i* at the right of the square represent the results that would be obtained by analyzing the sample by four different methods. The shaded portion of each rectangle shows the constituents on which the result is based, and the total area (except in *i*) shows the calcium carbonate content as calculated from this result. In *f* the total calcium, in whatever way combined, is determined and calculated to calcium carbonate. This is taken as correct, since we are concerned only with the calcium present and not with the carbon dioxide. In *g* the total carbon dioxide, in whatever way combined, is determined and calculated to calcium carbonate. With respect to the carbon dioxide, the result is slightly too high, because it includes the carbon dioxide not combined as calcium carbonate. However, the calcium present in the silicates is omitted. In *h* the total carbon dioxide is likewise included; but, in addition, a portion of the calcium and of the iron and aluminium in the siliceous materials have acid-consuming power. Theoretically, the analysis of this sample would be as follows:

| | Calcium carbonate. Per cent. |
|---|---|
| By permanganate titration | 75.05 + 2.19 = 77.24 |
| By calcimeter | 75.05 + 1.37 = 76.42 |
| By acid-alkali titration | 75.05 + 1.37 + 0.65 = 77.07 |

In general, both the calcimeter and the acid–alkali titration results are below the results obtained with potassium permanganate. Due to errors of the apparatus and of the process, however, the calcimeter results are frequently higher than the acid–alkali titration results. Up to the present it has not been found possible to obtain concordant results by any two of the three principal methods investigated, nor to discover a correction formula by which the results obtained by one of the indirect methods could be calculated to those of the direct method. Theoretically the true calcium carbonate content should be given by the formula:

$$\text{Percentage of calcium carbonate} = x + (100 - x)\,k,$$

in which $x$ is the percentage of calcium carbonate found by the calcimeter and $k$ is a constant depending on the amount of calcium in the siliceous materials. However, it may be seen from Table II that, due to irregularities in the composition of the raw materials, the clay contamination of the limestone, and certain phases of the manufacturing process, the constant, $k$, cannot be calculated with sufficient accuracy to justify the use of the formula.

When cement raw mixture enters a kiln and is gradually converted into clinker, results obtained by indirect methods of analysis are of course no longer applicable and any calculation of the

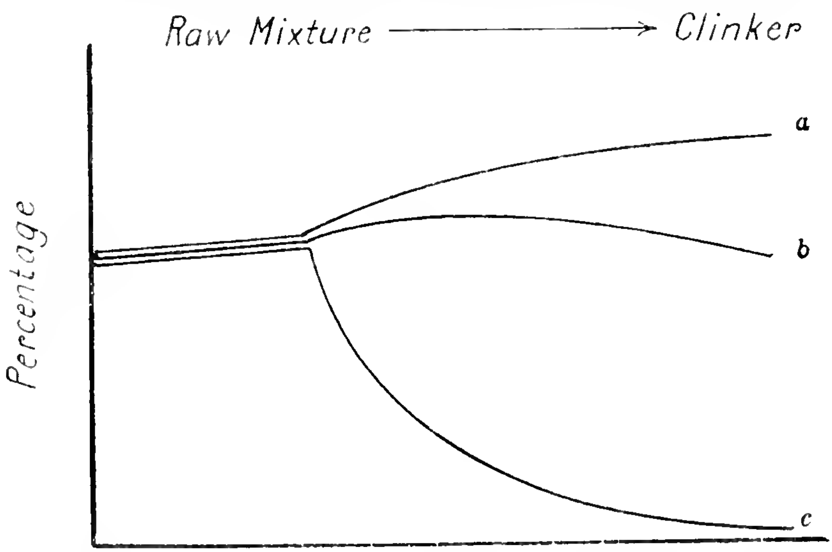



FIG. 2. Analysis of raw mixture at various stages of its conversion into clinker.

calcium present must be based on the determination of the calcium itself. The reason for this is shown in fig. 2, which is based on the analysis of a number of samples of raw mixture at various stages of conversion into clinker. Curve *a* shows total calcium; *b*, total alkalinity; and *c*, carbon dioxide—all calculated to percentage of calcium oxide. The raw mixture as it entered the kiln contained almost 44 per cent calcium oxide as indicated by the three methods of analysis, taking into account the errors, which have been explained.

The first part of all three curves rises, because during the first period no chemical change in the constituents of the mixture is taking place, and the percentage of calcium oxide is increasing because of the loss in moisture, organic matter, and the like. However, the change at once becomes pronounced, when the temperature becomes sufficiently high to decompose the limestone. Due to the loss in weight caused by the evolution of carbon dioxide, the percentage of calcium oxide present continually increases and the percentage of carbon dioxide decreases. The curve representing the alkalinity, or the acid-consuming value, of the mixture does not change so much as the other two. The factors that tend to make the curve rise and those having the reverse effect largely neutralize each other.[28]

## SUMMARY

In determining the calcium carbonate content of Portland cement raw mixture the methods available may be divided into two classes; namely, those in which the calcium is determined and those in which some other constituent is determined. Although some methods of the first class have been greatly shortened by several investigators, generally some method of the second class is employed in control work because of simplicity and rapidity. While all methods are subject to errors arising from the apparatus and from the procedure employed, errors due to the nature of the constituents of the raw mixture may greatly influence the results. The causes of errors that may arise have been studied.

[28] An investigation of certain phases of the subject is now in progress.

# ILLUSTRATIONS

## TEXT FIGURES

## REVIEW

The Elements of Animal Biology by S. J. Holmes, Ph. D. professor of zoölogy, University of California with 249 illustrations Philadelphia P. Blakiston's Son & Co. 1012 Walnut Street Cloth, pp. i–vii + 1–402, including index.

Professor Holmes's book, Elements of Animal Biology, is a high-school text in animal biology. It is divided into three sections: Part I, The Animal Kingdom; Part II, The Elements of Phisiology; and Part III, General Features and Adaptations. The part devoted to The Animal Kingdom gives the student an abbreviated but excellent idea of most of the important animals of the various groups, including their habits and in some cases their economic value and relation to disease.

The second part is introduced by a chapter on the Chemical Basis of Life and one on Cells and Tissues. The treatment is brief but adequate. A valuable chapter on Bacteria and Disease completes the part.

In the final part, General Features and Adaptations, evolution and heredity are considered, and the essential facts for a high-school student are presented.

The book is well written and interesting. It should be a valuable text for high schools that offer courses in animal biology.

R. P. C.

THE PHILIPPINE
# JOURNAL OF SCIENCE

VOL. XV AUGUST, 1919 No. 2

## ON THE APPLICATION OF THE GENERIC NAME MELODORUM OF LOUREIRO

By E. D. MERRILL
*Botanist, Bureau of Science, Manila*

The genus *Melodorum* was proposed by Loureiro[1] in 1790 for two species from Cochinchina, *Melodorum fruticosum* Lour. and *M. arboreum* Lour., of which the first is manifestly the type of the genus. While the description is not very definite, and while manifestly the fruit characters are based on material from some plant different from the type and in all probability not congeneric with it, it seems to be distinctly advisable to investigate the status of the genus in view of the misinterpretation of it in all modern botanical literature.

Fortunately for the purpose of this investigation Loureiro's type of *Melodorum fruticosum* is preserved in the herbarium of the British Museum, and through the kindness of Dr. A. B. Rendle and Mr. J. G. Baker I have been supplied with a sketch of it with certain notes regarding the specimen. The material consists of a leafy branch with the broken pieces of a flower, from which it was possible to sketch an entire petal.

After receiving the sketch mentioned above it was matched by material in the herbarium of the Bureau of Science and in order to verify my interpretation of Loureiro's species fragments of several specimens were forwarded to the British Museum for purposes of direct comparison with Loureiro's type. In reference to this material Doctor Rendle notes under date of July 3, 1919:

> Loureiro's plant is very much like the one labeled *Polyalthia siamensis* Boerl., cult. Hort. Bog.; the large petals seem identical in form but the

[1] Fl. Cochinch. (1790) 351.

prominent lateral veins of the leaf are rather less numerous (about 10 or 11 on each side) in Loureiro's plant, and also slightly farther apart. The twigs are also thicker in Loureiro's specimen. We find nothing that agrees better with it.

Dunal [2] seems to be the first author to adopt Loureiro's generic name, making it a section of the genus *Unona*. He referred both of Loureiro's species to *Unona; Melodorum fruticosum* Lour. = *Unona dumetorum* Dunal and *Melodorum arboreum* Lour. = *Unona sylvatica* Dunal. He saw no specimen but interpreted both species from Loureiro's descriptions. In proposing the section *Melodorum*, Dunal referred to it several other species; *Unona latifolia* Dunal = *Melodorum latifolium* Hook. f. & Th., *U. lucida* DC. = *Xylopia longifolia* A. DC., *Unona acutiflora* Dunal = *Xylopia* sp., *Unona xylopoides* Dunal, and *Unona polycarpa DC.* = *Xylopia polycarpa* Oliv.

In current botanical literature the authority for the generic name *Melodorum* is given as Hooker f. and Thomson,[3] but these authors credit the authority for the genus to Dunal, citing as synonyms *Unona*, section *Melodorum* Dunal; *Uvaria*, section *Melodorum* Blume; and *Polyalthia*, section *Kentia* Blume. Hooker f. and Thomson apparently interpreted the genus largely from the first species cited by Dunal; namely, the Malayan one currently known as *Melodorum latifolium* (Dunal) Hook f. & Th., described and figured by Blume as *Uvaria latifolia* Blume.[4]

Hooker f. and Thomson examined Loureiro's type of *Melodorum fruticosum* in the herbarium of the British Museum with the following comment:

> Loureiro's *Melodorum* is different, as we have determined by an inspection of the materials in the British Museum. In that collection there is an authentic specimen of *M. fruticosum* Lour., which is an undescribed plant, of doubtful affinity, as we have not examined the flower, but certainly not belonging to this genus. It has no fruit. There is no authentic specimen of *M. arboreum* Lour., but it is described as a large tree and is perhaps a *Mitrephora*.

While they excluded both of Loureiro's species from *Melodorum*, Hooker f. and Thomson considered it advisable to retain the generic name in the sense in which it was interpreted (in part) by Dunal and by Blume (as a section of *Unona* and of *Uvaria*). All subsequent authors have been content to follow Hooker f. and Thomson, and we hence have an entirely illogical

[2] Monogr. Fam. Anon. (1817) 98, 115, 116.

[3] Fl. Ind. (1855) 112.

[4] Fl. Jav. Anon. (1828) 37, *t. 15, 25A*.

case of a generic name proposed by Loureiro currently applied to a group of species quite different from Loureiro's original conception of the genus.

From an examination of the sketch of Loureiro's type kindly prepared by Mr. J. G. Baker I am confident that *Melodorum fruticosum* Lour. is the species currently known as *Polyalthia aberrans* Maingay and which has been variously described by several authors as *Polyalthia affinis* Teysm. & Binn., *P. siamensis* Boerl., and *Unona mesneyi* Pierre, and which was eventually transferred to *Popowia* by Pierre as *Popowia aberrans* Pierre. From this I cannot distinguish *Popowia diospyrifolia* Pierre by any satisfactory characters. Pierre [5] has given a detailed account of the characters of this species, indicating that it approaches *Popowia* in certain respects, but concluding that it cannot be referred to Endlicher's genus. He found that it is, in most respects, a *Polyalthia* but proposed for it the group name *Mesneya*, as a subgenus of *Unona*. Safford [6] has clearly shown that the so-called Old World species of *Unona* have nothing to do with *Unona* as originally described by the younger Linnaeus, this being an American genus, the proper generic name for the Old World species being *Desmos* Lour. King [7] notes that *Polyalthia aberrans* Maing., as interpreted by him, "save, and except in the much smaller size of the flowers," much resembles the plant figured and described by Pierre under the name of *Unona mesneyi*, and to which Pierre reduced *Polyalthia aberrans*. An examination of Cochinchina material now available to me for study and comparison shows that the size of the flowers in Pierre's drawing is greatly exaggerated, and that they are drawn all out of proportion to the leaves.

In interpreting the true status of *Melodorum* as described by Loureiro, we find that the type of the genus is a species aberrant in all of the genera in which it has been placed. It is to be noted that Pierre proposed for it the group name *Mesneya* (as a subgenus), and that Scheffer, quoted by Boerlage,[8] proposed for the same form the generic term *Sphaerocoryne*. For the present it seems best to retain *Melodorum* as a genus closely allied to *Popowia*, for which the names *Mesneya* Pierre and *Sphaerocoryne* Scheffer are exact synonyms. *Polyalthia*

[5] Fl. Forest. Cochinch. 1 (1880) *t. 17*.

[6] Bull. Torr. Bot. Club 39 (1912) 501-508.

[7] Ann. Bot. Gard. Calcutta 4 (1893) 78.

[8] Boerl. in Ic. Bogor. 1 (1899) 196, in nota sub *Polyalthia siamensis* Boerl.

Blume may then be retained for the numerous Indo-Malayan species currently so called, but the various species of *Melodorum* of all authors except Loureiro will need a new generic name, for which *Fissistigma* Griff. is available.

### MELODORUM Loureiro

MELODORUM FRUTICOSUM Lour. Fl. Cochinch. (1790) 351.

*Unona dumetorum* Dunal Monog. Anon. (1817) 31.

*Polyalthia* (?) *aberrans* Maingay in Hook. f. Fl. Brit. Ind. 1 (1874) 67; King in Ann. Bot. Gard. Calcutta 4 (1893) 78, *t. 109A*.

*Polyalthia affinis* Teysm. & Binn. in Nat. Tijdschr. Nederl. Ind. 27 (1864) 37; Boerl. in Ic. Bogor. 1 (1899) 124, 183, *t. 63*.

*Polyalthia siamensis* Boerl. in Ic. Bogor. 1 (1899) 124, 195, *t. 69*.

*Sphaerocoryne siamensis* Scheff. ex Boerl. l. c. in syn.

*Popowia aberrans* Pierre ex Finet & Gagnep. in Bull. Soc. Bot. France 53 (1906) Mem. 4: 109, et in Lecomte Fl. Gén. Indo-Chine 1 (1907) 83.

*Unona mesneyi* Pierre Fl. Forest. Cochinch. 1 (1880) *t. 17*.

*Popowia diospyrifolia* Pierre ex Finet & Gagnep. in Bull. Soc. Bot. France 53 (1906) Mém. 4: 110, et in Lecomte op. cit. 84. *t. 10, f. 11–19*.

*Melodorum glaucum* Scortech. ex King in Ann. Bot. Gard. Calcutta 4 (1893) 78, in syn.

*Melodorum clavipes* Hance in Journ. Bot. 15 (1877) 328.

There may be more than one species represented here, but if so they are very closely allied. According to Loureiro (*Melodorum fruticosum*), Boerlage (*Polyalthia affinis* Teysm. & Binn., *P. siamensis* Boerl.,), Pierre (*Unona mesneyi* Pierre), and Gagnepain (*Popowia aberrans* Pierre, *P. diospyrifolia* Pierre), it is an erect shrub or small tree, but according to Maingay and King it is a scandent shrub. The difference between *Polyalthia siamensis* Boerl. (*Polyalthia aberrans* Maing.) and *P. affinis* Teysm. & Binn. appears to me to be trivial. As between *Popowia aberrans* Pierre and *P. diospyrifolia* the same statement holds, the distinguishing character depended upon being only that of the stigma. It is to be noted that Finet and Gagnepain consider that Pierre's drawing of *Unona mesneyi*, as to the habit sketch, is *Popowia aberrans* Pierre, and as to the details of the flower, *P. diospyrifolia* Pierre.

The species extends from Indo-China to Siam and the Malay Peninsula and is in cultivation at Buitenzorg, Java. I have examined the following specimens: Indo-China, *Loureiro* (sketch of Loureiro's type as preserved in the herbarium of the British Museum, flowering specimen), *Thorel 391* (det. by Gagnepain as *Popowia diospyrifolia* Pierre, flowering specimen): Malay Peninsula, Pungah, *Curtis 2957*; Goping, *Kunstler 6136*; Ma-

lacca, *Burkill 2510;* Perak, *Scortechini 1946* (all these distributed as *Polyalthia aberrans* Maing., flowering specimens) : Java, *cult. Hort. Bogor XI–A–41–71* (four sheets, *Polyalthia siamensis* Boerl., flowering specimens from the type plant), *XI–A–63* (*Polyalthia affinis* Teysm. & Binn., flowering and fruiting specimens).

As several detailed descriptions of this species, as well as no less than four illustrations of it, with details of the flowers and fruits, have been published, it would seem that a further description is unnecessary. The genus *Melodorum* Lour., as I understand it, contains a single definitely known species, which while well defined and characteristic as a species presents a combination of characters which render it somewhat difficult to separate *Melodorum* from several not closely allied genera. It is clearly no *Unona* (that is, *Desmos*) ; and it is equally aberrant in *Polyalthia* and in *Popowia*, the two other genera in which it has been placed. I am personally of the opinion that *Melodorum* as originally described by Loureiro and typified by *Melodorum fruticosum* Lour. (not of modern authors) is a valid genus, more closely allied to *Popowia* than to *Polyalthia*, and that it belongs in the tribe *Mitrephorae*. Pierre in his critical discussion of *Unona mesneyi* notes that Maingay described the inner petals as imbricate in bud, but that he found them to be perfectly valvate in Wallich's specimen. Both series of petals touch by their thickened margins, and those of the inner series remain in this position long after anthesis. I have seen no fresh material of *Melodorum fruticosum*, but the figures given by Pierre, Boerlage, and King present the outer series of petals as more or less spreading in anthesis; in all the herbarium specimens examined by me none of the petals are spreading. The persistent valvate position of the inner petals is a character by which the genus can be readily distinguished from *Polyalthia* and all the other genera in the tribe *Unonae;* while in the *Mitrephorae* it is readily distinguished from *Fissistigma* Griff. (*Melodorum* auct., non Lour.) by its globose buds and more or less spreading (?) outer petals; from *Popowia* Endl., which seems to be its true alliance, it differs entirely not only in its facies, but also in its larger, long-pedicelled flowers; in its outer petals, which are much larger and entirely different from the sepals; and by the inner petals being valvate by their much thickened margins but not connivent.

*Melodorum arboreum* Lour.[9] = *Unona sylvatica* Dunal,[10] the

[9] Fl. Cochinch. (1790) 351.

[10] Monog. Anon. (1817) 91.

second species of the genus described by Loureiro, is one of doubtful status, but in all probability is not congeneric with *Melodorum fruticosum* Lour. It is described as a large tree growing in forests, the leaves tomentose beneath, the calyx and corolla as in *Melodorum fruticosum* Lour. The indicated floral characters can be considered as no more than approximate. Hooker f. and Thomson have suggested that this may prove to be a *Mitrephora* and, from the description and the various species of *Mitrephora* now known from Indo-China, I strongly suspect that Loureiro's species is the same as *Mitrephora thorelii* Pierre.

It is perfectly evident that whatever disposition be made of *Melodorum* as originally described by Loureiro, whether it be considered as a valid genus allied to *Popowia*, or whether it be considered as synonymous with *Popowia*, or with *Polyalthia*, it can no longer be retained in the sense in which it is currently used; that is, as erroneously interpreted by Hooker f. and Thomson. The genera proposed by other authors currently considered as synonyms of *Melodorum* Hook. f. & Th., are *Fissistigma* Griff. (1854), *Mitrella* Miq. (1865), and *Pyramidanthe* Miq. (1865). Of these *Fissistigma* Griff. is an exact synonym of *Melodorum* as interpreted by Hooker f. and Thomson and antedates *Melodorum* as used by the latter authors by one year. It is typified by *Fissistigma scandens* Griff.[11] I accordingly propose to adopt Griffith's generic name for the numerous species currently but erroneously known as *Melodorum*. Boerlage[12] retains *Kentia* Miq. and *Pyramidanthe* Miq. as valid genera allied to *Melodorum* Hook. f. & Th., that is, *Fissistigma* Griff.; but in this consideration of the case I have followed current usage and have reduced both to *Fissistigma*.

### FISSISTIGMA Griffith

(*Melodorum* auct. plur., non Lour.)

**FISSISTIGMA AFRICANUM** (Benth.).

*Melodorum africanum* Benth. in Trans. Linn. Soc. 23 (1862) 477.

Africa.

**FISSISTIGMA BALANSAE** (Aug. DC.).

*Melodorum balansae* Aug. DC. in Bull. Herb. Boiss. II 4 (1904) 1070; Finet & Gagnep. in Lecomte Fl. Gén. Indo-Chine 1 (1907) 104.

Indo-China.

[11] Notul. 4 (1854) 706.
[12] Ic. Bogor. 1 (1899) 129, 130.

FISSISTIGMA BECCARII (Scheff.).

*Melodorum beccarii* Scheff. in Ann. Jard. Bot. Buitenz. 2 (1885) 24.
*Mitrella beccarii* Diels in Engl. Bot. Jahrb. 49 (1912) 149.

New Guinea.

FISSISTIGMA BICOLOR (Roxb.).

*Uvaria bicolor* Roxb. Fl. Ind. ed. 2, 2 (1832) 662.
*Melodorum bicolor* Hook. f. & Th. Fl. Ind. (1855) 119; King in Ann. Bot. Gard. Calcutta 4 (1894) 133, *t. 175B.*

Eastern Himalayan region to Assam and Burma.

FISSISTIGMA BORNEENSE (Miq.)

*Melodorum borneense* Miq. in Ann. Mus. Bot. Lugd.-Bat. 2 (1865) 36.

Borneo.

FISSISTIGMA CINERASCENS (Miq.).

*Melodorum cinerascens* Miq. Ann. Mus. Bot. Lugd.-Bat. 2 (1865) 37.

Sumatra.

FISSISTIGMA CHRYSOSERICEUM (Finet & Gagnep.).

*Melodorum chrysosericeum* Finet & Gagnep. in Bull. Soc. Bot. France 54 (1907) 88, et in Lecomte Fl. Gén. Indo-Chine 1 (1907) 98, *f. 12.*

Indo-China, *Thorel 2429!*

FISSISTIGMA CYLINDRICUM (Maingay).

*Melodorum cylindricum* Maingay in Hook. f. Fl. Brit. Ind. 1 (1872) 80; King in Ann. Bot. Gard. Calcutta 4 (1893) 136, *t. 177B.*
*Melodorum cylindraceum* Boerl. in Ic. Bogor. 1 (1899) 133.

Malay Peninsula, Singapore, Borneo, *Ridley 1823!, s. n.!*

FISSISTIGMA ELEGANS (Wall.).

*Uvaria elegans* Wall. Cat. (1832) No. 6474A, *nomen nudum.*
*Melodorum elegans* Hook. f. & Th. Fl. Ind. (1855) 122; King in Ann. Bot. Gard. Calcutta 4 (1893) 141, *t. 184B.*

Malay Peninsula, Penang, *Wray 1079!, King's collector 6367!, Kunstler 5115!, Ridley 13516!, s. n.!*

FISSISTIGMA FAGIFOLIUM (Ridl.).

*Melodorum fagifolium* Ridl. in Kew Bull. (1912) 286.

Borneo, *Hose 397!*

FISSISTIGMA FULGENS (Wall.).

*Uvaria fulgens* Wall. Cat. (1832) No. 6482, *nomen nudum.*
*Mitrephora fulgens* Hook. f. & Th. Fl. Ind. (1855) 120; King in Ann. Bot. Gard. Calcutta 4 (1893) 132, *t. 174.*

Malay Peninsula, Singapore, Borneo (not in the Philippines!), *Kunstler 2654!, Haniff & McNur 2317!, Wray 2441! Ridley 4587!*

FISSISTIGMA GLAUCESCENS (Hance).

*Melodorum glaucescens* Hance in Journ. Bot. 19 (1881) 112.

Hongkong.

FISSISTIGMA HYPOGLAUCUM (Miq.).

*Melodorum hypoglaucum* Miq. Ann. Mus. Bot. Lugd.-Bat. 2 (1865) 37; King in Ann. Bot. Gard. Calcutta 4 (1893) 136, *t. 180A*.

Malay Peninsula, Borneo, Sumatra, *King's collector 5060!, 5806!, 1022!*

FISSISTIGMA KENTII (Blume).

*Unona kentii* Blume Bijdr. (1825) 16.
*Polyalthia kentii* Blume Fl. Jav. Anon. (1828) 77, *t. 38, 52A*.
*Melodorum kentii* Hook. f. & Th. Fl. Ind. (1855) 116.
*Mitrella kentii* Miq. Ann. Mus. Bot. Lugd.-Bat. 2 (1865) 39; Boerl. in Ic. Bogor. 1 (1899) 130, *t. 43, f. C*.

Java, cult. Hort. Bogor. *XI-A-29-64!* Boerlage, l. c., retains this as a distinct genus.

FISSISTIGMA KINABALUENSE (Stapf).

*Melodorum kinabaluense* Stapf in Trans. Linn. Soc. Bot. 4 (1894) 130.

Borneo.

FISSISTIGMA KORTHALSII (Miq.).

*Melodorum korthalsii* Miq. Ann. Mus. Bot. Lugd.-Bat. 2 (1865) 37.

Borneo.

FISSISTIGMA LANUGINOSUM (Hook. f. & Th.).

*Melodorum lanuginosum* Hook. f. & Th. Fl. Ind. (1855) 117; in Ann. Bot. Gard. Calcutta 4 (1893) 138, *t. 182*.
*Uvaria tomentosa* Wall. Cat. (1832) No. 6454, *nomen nudum*.

Malay Peninsula, Penang, Singapore, Indo-China, *King's collector 4664!, 7890!, 4581!, Hullett s. n.!, Ridley s. n.!*

FISSISTIGMA LATIFOLIUM (Dunal).

*Unona latifolia* Dunal Monog. Anon. (1817) 115.
*Uvaria longifolia Blume* Bijdr. (1825) 13.
*Uvaria latifolia* Blume Fl. Jav. Anon. (1828) 37, *t. 15*.
*Melodorum mollissimum* Miq. Fl. Ind. Bat. Suppl. (1861) 374.
*Melodorum latifolium* Hook. f. & Th. Fl. Ind. (1855) 116; King in Ann. Bot. Gard. Calcutta 4 (1894) 135, *t. 178*.

Malay Peninsula (Perak), Java, Mt. Salak, *ex herb. Bogor.!* collector not indicated. Borneo, Indo-China, fide Gagnepain, Moluccas.

The type of this species is *Cananga sylvestris III latifolia* Rumph.[13] of Amboina. The species is currently interpreted from Blume's figure and description which were based on Javan material. Boerlage expresses the opinion that *Melodorum mollissimum* Miq. is specifically distinct from *M. latifolium* Hook. f. & Th.

FISSISTIGMA LEICHHARDTII (Benth.).

*Melodorum leichhardtii* Benth. Fl. Austral. 1 (1863) 52.

Australia (Queensland, N. S. Wales), *White! Boorman!*

FISSISTIGMA LITSAEFOLIUM (King).

*Melodorum litsaefolium* King in Journ. As. Soc. Beng. 61[2] (1892) 103, Ann. Bot. Gard. Calcutta 4 (1893) 132, *t. 173*.

Malay Peninsula, Perak, *King's collector 4986!, 7063.*

FISSISTIGMA LONGIPETALUM (Ridl.).

*Melodorum longipetalum* Ridl. in Kew Bull. (1912) 387.

Borneo.

FISSISTIGMA MABIFORME (Griff.).

*Uvaria mabiformis* Griff. Notul. 4 (1854) 709.
*Melodorum pisocarpum* Hook. f. & Th. Fl. Ind. (1855) 123; King in Ann. Bot. Gard. Calcutta 4 (1893) 142. *t. 187A*.
*Melodorum pyramidale* Maingay ex King l. c. in syn.

Malay Peninsula, Singapore, Sumatra, *King's collector 6411!, 10602!, Forbes 2182!, Ridley s. n.!*

FISSISTIGMA MACCREAI (F. Muell.).

*Melodorum maccreai* F. Muell. Fragm. 6 (1867) 176.

Australia.

FISSISTIGMA MACRANTHUM (Kurz).

*Melodorum macranthum* Kurz in Journ. As. Soc. Beng. 41[2] (1872) 291; King in Ann. Bot. Gard. Calcutta 4 (1892) 140, *t. 186*.
*Unona macrantha* Kurz in Andam. Rep. (1867) App. B. 1.
*Pyramidanthe macrantha* Kurz op. cit. ed. 2 (1870) 29.

South Andaman, *Kurz!*

FISSISTIGMA MAINGAYI (Hook. f. & Th.).

*Melodorum maingayi* Hook. f. & Th. Fl. Ind. (1855) 139; King in Ann. Bot. Gard. Calcutta 4 (1893) 139, *t. 184A*.

Malay Peninsula, Penang, Borneo, *Wray 1112!*

[13] Herb. Amb. 2: 198.

FISSISTIGMA MANUBRIATUM (Wall.).

*Uvaria manubriata* Wall. Cat. (1832) No. 6456, *nomen nudum*.
*Melodorum manubriatum* Hook. f. & Th. Fl. Ind. (1855) 118; King in Ann. Bot. Gard. Calcutta 4 (1893) 134, *t. 176*.
*Melodorum bancanum* Scheff. in Nat. Tijdschr. Nederl. Ind. 31 (1870) 343, Flora 53 (1870) 244.

Malay Peninsula, Penang, Bangka, Borneo. *Kunstler 7832!, King's collector 4948!, 5786!, Ridley 4712!, Cult. Hort. Bogor. XVI–E–107!, XI–A–45–67!*

FISSISTIGMA OBLONGUM (Craib).

*Melodorum oblongum* Craib in Kew Bull. (1914) 5.

Siam, *Kerr 1879!*

FISSISTIGMA OLDHAMII (Hemsl.).

*Melodorum oldhamii* Hemsl. in Journ. Linn. Soc. Bot. 23 (1886) 27.

Formosa, Southern China, *Dunn 6339!, Faurie 430!, Tutcher 1052!, Japanese collector 1292!*

FISSISTIGMA OVALIFOLIUM (Ridl.).

*Melodorum ovalifolium* Ridl. in Kew Bull. (1912) 387.

Borneo.

FISSISTIGMA OVOIDEUM (King).

*Melodorum latifolium* Hook. f. & Th. var. *ovoidea* King in Journ. As. Soc. Beng. 61[2] (1892) 106, Ann. Bot. Gard. Calcutta 4 (1893) 135, *t. 179*.

Malay Peninsula, Singapore, *King's collector 8119!, 10418!, Burkill!*

This differs remarkably from the typical form of *Melodorum latifolium* as figured and described by Blume in its very much larger, entirely different fruits, and is certainly worthy of specific rank.

FISSISTIGMA PALLENS (Finet & Gagnep.).

*Melodorum pallens* Finet & Gagnep. in Bull. Soc. Bot. France 53 (1906) Mém. 4: 137, et in Lecomte Fl. Gén. Indo-Chine 1 (1907) 100, *t. 11, f. 7–11*.

Indo-China.

FISSISTIGMA PANICULATUM (Ridl.).

*Melodorum paniculatum* Ridl. in Kew Bull. (1912) 386.

Borneo.

FISSISTIGMA PARVIFLORUM (Scheff.).

*Melodorum parviflorum* Scheff. in Nat. Tijdschr. Nederl. Ind. 31 (1870) 344, Flora 53 (1870) 244; King in Ann. Bot. Gard. Calcutta 4 (1893) 137, *t. 181*.

Malay Peninsula, Bangka, Borneo, *King's collector 7276! 8366!, 6498!*

FISSISTIGMA POLYANTHOIDES (Aug. DC.).

*Melodorum polyanthoides* Aug. DC. in Bull. Herb. Boiss. II 4 (1904) 1070; Finet & Gagnep. in Lecomte Fl. Gén. Indo-Chine 1 (1907) 103.

Indo-China, *Thorel 2431!*

FISSISTIGMA POLYANTHUM (Wall.).

*Uvaria polyantha* Wall. Cat. (1831) No. 6467, *nomen nudum*.
*Melodorum polyanthum* Hook. f. & Th. Fl. Ind. (1855) 121; King in Ann. Bot. Gard. Calcutta 4 (1893) 131, *t. 172A*.

Chittagong.

FISSISTIGMA PRISMATICUM (Hook. f. & Th.).

*Melodorum polyanthum* Hook. f. & Th. Fl. Ind. (1855) 121; King in Ann. Bot. Gard. Calcutta 4 (1894) 140, *t. 185*.
*Uvaria rufa* Wall. Cat. (1832) No. 6455, *nomen nudum*.
*Pyramidanthe rufa* Miq. Ann. Mus. Bot. Lugd.-Bat. 2 (1863) 39; Boerl. in Ic. Bogor. 1 (1899) 130, *t. 43, f. D*.
*Oxymitra bassiaefolia* Teysm. & Binn. in Nat. Tijdschr. Nederl. Ind. 25 (1863) 419.

Malay Peninsula, Singapore, Borneo, *King's collector 5737!, 3932!, Baker 5705!*

Boerlage retains *Pyramidanthe* Miquel as a genus distinct from *Melodorum* (*Fissistigma*).

FISSISTIGMA PUNCTULATUM (Baill.).

*Melodorum punctulatum* Baill. in Adansonia 10 (1871) 107.

New Caledonia.

FISSISTIGMA RIGIDUM (Ridl.).

*Melodorum rigidum* Ridl. in Kew Bull. (1912) 386.

Borneo.

FISSISTIGMA RUBIGINOSUM (A. DC.).

*Uvaria rubiginosa* A. DC. in Mém. Soc. Phys. Genèv. 5 (1832) 202.
*Uvaria nervosa* Wall. Cat. (1832) No. 6479, *nomen nudum*.
*Uvaria fulva* Wall. op. cit. No. 6427, *nomen nudum*.
*Melodorum rubiginosum* Hook. f. & Th. Fl. Ind. (1855) 138; King in Ann. Bot. Gard. Calcutta 4 (1893) 138, *t. 183*.

Sylhet to Chittagong, Tenasserim, Penang (var. *oblongum* King, *King's collector 5082!*), Indo-China, and Borneo.

FISSISTIGMA RUFINERVE (Hook. f. & Th.).

*Melodorum rufinerve* Hook. f. Th. Fl. Ind. 1 (1855) 121; King in Ann. Bot. Gard. Calcutta 4 (1893) 130, *t. 171B.*

India.

FISSISTIGMA RUFUM (Presl).

*Anona rufa* Presl Rel. Haenk. 2 (1830) 75.
*Melodorum clementis* Merr. in Philip. Journ. Sci. 3 (1908) Bot. 136.
*Melodorum rufum* Merr. op. cit. 223.

This species was originally described from Luzon material and it extends from central Luzon to Mindanao. It is closely allied to *Fissistigma latifolium* (Dunal) Merr. (*Melodorum latifolium* Hook. f. & Th.), and Philippine specimens of it have been referred to the latter species.

FISSISTIGMA SCANDENS Griff. Notul. 4 (1854) 706.

*Melodorum griffithii* Hook. f. & Th. Fl. Ind. (1855) 120; King in Ann. Bot. Gard. Calcutta 4 (1893) 131, *t. 172B.*

Burma, Indo-China.

FISSISTIGMA SCHLECHTERI (Diels).

*Mitrella schlechteri* Diels in Engl. Bot. Jahrb. 49 (1912) 150.

New Guinea.

FISSISTIGMA SCHEFFERI (Pierre).

*Melodorum schefferi* Pierre ex Finet & Gagnep. in Bull. Soc. Bot. France 53 (1906) Mém. 4: 134, et in Lecomte Fl. Gén. Indo-Chine 1 (1907) 99, *t. 13, f. 1–8.*

Indo-China.

MELODORUM SPHAEROCARPUM (Blume) Miq. Fl. Ind. Bat. 1² (1858) 35; King in Ann. Bot. Gard. Calcutta 4 (1893) 137, *t. 180B.*

*Unona sphaerocarpa* Blume Bijdr. (1825) 12, Fl. Jav. Anon. (1828) 39, *t. 16.*

Malay Peninsula, Java, *King's collector 4002!, Backer 25558!*

FISSISTIGMA THORELII (Pierre).

*Melodorum thorelii* Pierre ex Finet & Gagnep. in Bull. Soc. Bot. France 53 (1906) Mém. 4: 133, et in Lecomte Fl. Gén. Indo-Chine 1 (1907) 97, *t. 14, f. 1–6.*

Indo-China.

FISSISTIGMA TONKINENSE (Finet & Gagnep.).

*Melodorum tonkinense* Finet & Gagnep. in Bull. Soc. Bot. France 53 (1906) Mém. 4: 135, et in Lecomte Fl. Gén. Indo-Chine 1 (1907) 100, *t. 12, f. 1–6.*

Indo-China.

FISSISTIGMA UHRII (F. Muell.).

*Melodorum uhrii* F. Muell. Fragm. 6 (1867) 2.

Australia.

FISSISTIGMA UONICUM (Dunn).

*Melodorum uonicum* Dunn in Journ. Bot. 48 (1910) 323.

Hongkong.

FISSISTIGMA VERRUCOSUM (Hook. f. Th.).

*Melodorum verrucosum* Hook. f. & Th. Fl. Ind. (1855) 119; King in Ann. Bot. Gard. Calcutta 4 (1893) 134, *t. 177A*.

India. The Hainan specimen referred here by Hance probably represents some other species.

FISSISTIGMA WALLICHII (Hook. f. & Th.).

*Melodorum wallichii* Hook. f. & Th. Fl. Ind. (1855) 118; King in Ann. Bot. Gard. Calcutta 4 (1894) 133, *t. 175A*.

*Uvaria bicolor* Wall. Cat. (1832) No. 6466, *nomen nudum*, non Roxb.

Assam, Khasia, and Sylhet.

FISSISTIGMA ZIPPELII (Miq.).

*Melodorum zippelii* Miq. Ann. Mus. Bot. Lugd.-Bat. 2 (1865) 38.

Sumatra.

## DOUBTFUL AND EXCLUDED SPECIES

MELODORUM MICRANTHUM Warb. in Engl. Bot. Jahrb. 18 (1893) 190 = *Papualthia longirostris* (Scheff.) Diels in Engl. Bot. Jahrb. 49 (1912) 140, *f. 1, G-H* (*Goniothalamus longirostris* Scheff., *G. inaequilaterus* K. Schum. & Lauterb.).

MELODORUM LEFEVRII Baill. in Adansonia 10 (1871) 108. The type was from Indo-China. I can find no mention of the species in Finet & Gagnepain's treatment of the Annonaceae of Indo-China in Lecomte Fl. Gén. Indo-Chine 1 (1917) 42–123.

# THE JUMPING PLANT LICE OF THE PALÆOTROPICS AND THE SOUTH PACIFIC ISLANDS

## FAMILY PSYLLIDÆ, OR CHERMIDÆ, HOMOPTERA

By David L. Crawford

*Of the College of Hawaii, Honolulu*

THREE PLATES AND THREE TEXT FIGURES

Our knowledge of the psyllid fauna of the Old World Tropics is gradually being extended, though it is far from complete. It appears that the subfamilies Pauropsyllinæ and Carsidarinæ are much more extensively represented in this part of the world than in either the North or the South Temperate Zone, and perhaps are the chief groups in numbers of species.

This family is widely distributed and often numerously represented, even on the Pacific islands. Some very interesting evolutional features are to be noted in the psyllid faunæ of certain island groups. The most remarkable is that of the Hawaiian Archipelago, where thirteen of the fifteen known species are apparently derivatives of one species long ago established here. Some of these species have diverged so far from the ancestral type, a *Trioza*, that two other generic groups embrace them.

In the Malay Archipelago there is another interesting group, *Megatrioza*. This genus of the Triozinæ is most numerously represented in this Archipelago but extends into the Philippines and south into Australasia, and one species has found its way as far as the Hawaiian Islands. Several other genera, more fully treated on subsequent pages, appear to have sprung from this one.

Economically, this family is of less importance than the Aphididæ and much less than the Coccidæ. A few species in the Palæotropics cause considerable damage, and no doubt when the habits of certain other species are known the number of economically important species will be augmented.

Buckton's *Psylla isitis* (probably the same as *Arytaina punctipennis* Crawford '12: 431) is a pest on indigo; and *Euphalerus citri*, on citrus trees. The habits of the majority of the species herein described are unknown.

A detailed description of the anatomy and the taxonomy of the family, as a whole, is given in my monograph and need not be repeated here. However, a key to the subfamilies represented in the Old World Tropics is included here for convenience.

This taxonomic work is made possible chiefly through the extensive collecting activities of Prof. C. F. Baker and of Mr. Frederick Muir.

*Key to the subfamilies of the Psyllidæ.*

*a*[1]. Frons usually visible as a small sclerite, bearing front ocellus; genæ seldom produced into processes; body short and robust; thorax strongly arched, head strongly deflexed; coxal spurs short.
Pauropsyllinæ Crawford.

*a*[2]. Frons covered by genæ and not visible, except a very narrow border around front ocellus; body usually more elongate; coxal spurs usually not very short.

*b*[1]. Genal processes (cones) usually wanting and head deeply cleft in front between the antennæ or, if head is not cleft, the forewings have one or two pseudo (cross) veins; body typically long and slender; forewings elongate and often with pseudoveins; basal tarsus of hind legs usually with only one clawlike spine at apex.
Carsidarinæ Crawford.

*b*[2]. Genal processes (cones) usually present and head not cleft in front, except as the divergent genal cones may give the appearance of a cleft; forewings never with pseudoveins.

*c*[1]. Forewings with cubital petiole (media and cubitus with a common stem); basal tarsus of hind legs with two clawlike spines at apex.
Psyllinæ Puton.

*c*[2]. Forewings usually without cubital petiole (the radius, media, and cubitus all emerging from basal vein at the same point); basal tarsus of hind legs with no clawlike spines at apex.
Triozinæ Puton.

## PAUROPSYLLINÆ

Body robust; thorax strongly arched, broad; head short, much deflexed, rounded forward and downward, with eyes prominent; genal cones usually wanting or small and not prominent; frons usually visible, bearing the anterior ocellus at upper end; antennæ usually short, often with long setæ at apex. Legs slender and usually not large. Forewings large, usually broadly rounded at the apex, venation various. Many of the species of this subfamily are gall makers.

*Key to the genera.*

*a*. Genæ not produced into distinct conical processes, but sometimes more or less swollen beneath (somewhat conical in *Paurocephala magnifrons* Crawford.

$b^1$. Hind legs not larger than middle pair, apparently not saltatory, hind coxæ small, and coxal spur nearly wanting.... Apsylla Crawford.

$b^2$. Hind legs longer than middle pair, apparently saltatory; metacoxæ much larger than mesocoxæ, and metacoxal spur well developed.

$c^1$. Forewings membranous, more or less transparent.

$d^1$. Media, cubitus, and radius not forking at same point from basal vein; hind wings not nearly wanting.

$e^1$. Antennæ short, seldom longer than head and thorax combined; head usually much deflexed and retracted into large prothorax.

$f^1$. First marginal cell of forewing narrow and long, paralleling posterior margin; media-cubital stem as long or nearly as long as radial stem; metacoxal spur usually long, four to eight times as long as thick; antennæ usually longer than width of head; genæ sometimes swollen conspicuously beneath antennal bases................ Paurocephala Crawford.

$f^2$. First marginal cell not narrow and long; media-cubital stem usually shorter than radial stem or wanting. Metacoxal spur usually very short, one to three times as long as thick; antennæ typically very short, seldom longer than width of head; genæ seldom swollen.

Pauropsylla Rübsaamen.

$e^2$. Antennæ longer than head and thorax combined; head less deflexed and retracted into prothorax.

$f^1$. Antennæ not longer than body to tip of abdomen; metascutum with two prominent hornlike epiphyses projecting upward ................ Diceraopsylla Crawford.

$f^2$. Antennæ very long and slender, longer than body to tip of abdomen; metascutum without horns; genæ swollen, often spherical beneath antennal bases.

Heteropsylla Crawford.

$d^2$. Media, cubitus, and radius of forewing forking from basal vein at same point (as in Triozinæ); cubital vein unforked at apex; hind wings nearly wanting............ Leptynoptera g. nov.

$c^2$. Forewings nearly or quite opaque, more or less coriaceous; veins greatly contorted; front tibiæ foliaceous...... Heteroneura g. nov.

$a^2$. Genæ swollen beneath into two more or less conical processes, these usually quite separated at base.

$b^1$. First marginal cell of forewing long and narrow with $Cu_1$ more or less parallel with margin of wing.......... Paurocephala Crawford.

$b^2$. First marginal cell of forewing not long and narrow, $Cu_1$ not parallel with margin.

$c^1$. Body large; radial sector and media connected by a cross vein; first marginal cell small, much smaller than second.

Phacopteron Buckton.

$c^2$. Body small; cross vein wanting; first marginal cell very large, much larger than second; genal cones in some species scarcely discernible.................. Calophya Loew.

## Genus PAUROPSYLLA Rübsaamen

*Key to the species.**

$a^1$. Forewing with pterostigma.

$b^1$. Antennæ with two or more very long setæ at tip.

$c^1$. Antennæ much shorter than width of vertex between eyes; vertex showing median suture distinctly.

$d^1$. Antennæ with eight long setæ, tassellike. (Malay Archipelago.) **P. brevicornis** sp. nov.

$d^2$. Antennæ with two long setæ, not tassellike. (Bengal.) **P. nigra** sp. nov.

$c^2$. Antennæ about as long as width of vertex between eyes, with three long setæ; vertex with median suture not visible. (Malay Archipelago.) .......... **P. verticis** sp. nov.

$b^2$. Antennæ without long terminal setæ.

$c^1$. Forewing broadly rounded, marginal cells moderately large, pterostigma narrow; insect of medium size. (Ceylon.) **P. spondiasæ** Crawford ('15: 260).

$c^2$. Forewing acute at apex, broad, marginal cells very large, pterostigma elliptical, broad; insect large. Malay Archipelago; Hawaii?) .......... **P. apsylloides** sp. nov.

$a^2$. Forewings without pterostigma.

$b^1$. Second marginal cell much larger than first; fourth furcal ($M_{1+2}$) angulately arched and touching radius.

$c^1$. Insect minute, about 2 millimeters long from head to tip of folded wings; forewings with black spots scattered along veins; first marginal cell about one-third as large as second. (Ceylon.) **P. floccosa** Crawford ('15: 259).

$c^2$. Insect larger, 3 millimeters long or longer; forewing veins without black dots; first marginal cell about one-tenth as large as second. (Bengal.) .......... **P. tuberculata** Crawford ('12: 430).

$b^2$. Second marginal cell not larger than first, usually subequal; fourth furcal not touching radius.

$c^1$. Media and cubitus without stem, the radius, media, and cubitus forking from basal vein at same point (as in *Trioza*). (Philippines and Java.) .......... **P. triozoptera** Crawford ('13: 296).

$c^2$. Media and cubitus with a short stem, not as above.

$d^1$. Head and thorax black, reticulately marked; anterior ocellus above, near posterior ocelli; abdomen large, not flattened. (Philippines and Java.) .......... **P. udei** Rübsaamen ('99: 264).

$d^2$. Head and thorax reddish or light brown, reticulation indistinct; anterior ocellus in front, more distant from posterior ocelli. (Bengal.) .......... **P. depressa** Crawford ('12: 429).

**Pauropsylla brevicornis** sp. nov. Plate I, figs. 1 and 2.

Length of body, 1.3 millimeters; length of forewing, 1.9. General color reddish to chocolate brown, with venter of

* Because of lack of knowledge concerning them I have not included in this key *Pauropsylla ficicola* Kieffer and *P. globuli* Kieffer.

abdomen and metathorax whitish or pale greenish yellow; legs and antennæ yellowish or pale; wings membranous, clear. Body small, but robust.

Head small, much deflexed, appearing very short from dorsal aspect, not as broad as thorax; vertex roundly convex from frontal view, without prominent foveal impressions, slightly elevated at posterior ocelli; anterior ocellus visible from front, at lower margin of vertex; frons not visible; genæ mostly concealed by retraction of head toward thorax; clypeus and beak small. Eyes small. Antennæ very short, not half as long as width of head, with several very long, slender setæ giving the antennæ a tassellike appearance.

Thorax short and well arched. Legs short, small and slender, spines very inconspicuous. Forewings broad and rounded at apex, veins slender and not prominent.

Male: Genital segment small, short; forceps nearly as long as anal valve, very slender, tapering to acute apex, somewhat bent forward in apical third; anal valve broadest at base, converging to narrow apex. Female: Genital segment not quite as long as rest of abdomen, dorsal valve a little larger than ventral, truncate at apex.

TENIMBER ISLANDS, Larat (*Muir*), 1 male and 2 females.

Pauropsylla nigra sp. nov.

Length of body, 1.2 millimeters; forewing, 1.6. General color shining black; vertex and thorax dorsad glossy black, abdomen black above and below with connective membrane orange yellow. Genæ orange ventrad, thoracic venter orange in part and the rest black; antennæ yellowish; legs yellowish except hind femora, which are mostly black.

Structurally very similar to *Pauropsylla brevicornis*, differing in the following characteristics: Antennæ about one-third as long as width of head, with only two long setæ, these both at the tip and as long as the antennæ. Forewings shaped and veined much as in the related species but a little smaller.

Female genitalia similar but with a pair of small projections from caudal end between dorsal and ventral valves.

INDIA, Pusa, Bihar (*C. S. Misra*), September 5, 1914, 1 female, found in the laboratory.

Pauropsylla verticis sp. nov. Plate I, figs. 3 and 4.

Length of body, 2.3 millimeters, forewing 2.5. General color

light brown with darker streaks on dorsum; venter of thorax pale whitish with a few brown streaks; abdomen mostly dark brown; antennæ and legs light yellowish brown; wings clear.

Head strongly declivous, not as broad as thorax. Vertex somewhat quadrate in outline, nearly perpendicular to axis of body, nearly as long as broad, median suture not visible, surface without depressions, broadly convex and not flat, front portion extended forward between antennal bases. Frons small, visible from in front. Genæ slightly swollen beneath antennal sockets. Antennæ short, about as long as width of vertex between eyes, with three long setæ at end of each. Eyes large, recessive.

Thorax broad, well arched. Legs rather slender; hind tibiæ without basal spur. Forewings hyaline, clear, narrowly rounded at apex, veins narrow, yellow; pterostigma narrow, radius short; first marginal cell (in both forewings of the only specimen at hand) divided transversely across the middle.

Female genital segment nearly as long as abdomen, rather slender, dorsal valve a little longer than ventral, with a serrated carina along apical dorsal portion; both valves acutely pointed.

TENIMBER ISLANDS, Larat (*Muir*), 1 female.

This species is remarkable because of its vertex, which is without a visible median suture. The divided marginal cell of forewing is probably not a constant specific character but only an abnormality.

**Pauropsylla apsylloides** sp. nov. Plate I, fig. 7.

Length of body, 2.9 millimeters; forewing, 4.2. General color light to dark brown, sometimes with dirty brown blotches on thoracic dorsum; eyes dark; forewing clear, with four brown spots on posterior margin and one at apical end of pterostigma. Body large and robust; surface reticulately marked.

Head strongly declivous, not quite as broad as thorax. Vertex nearly perpendicular to axis of body, about three times as broad as length down median suture, arcuately concave on posterior margin; frons visible between genæ, with large front ocellus at apex; clypeus large, visible below frons. Genæ swollen beneath antennal sockets. Antennæ about as long as width of vertex between eyes, sometimes a little longer, relatively thick, segments short and terminal setæ rather short. Eyes large, recessive over propleurites.

Thorax very broad and robust, strongly arched, and finely reticulately marked. Legs short and thick; hind tibiæ short, without basal spur, four thick, black spines at apex within.

Forewings very large and broad, hyaline, clear, acutely pointed, veins slender; marginal cells very large; pterostigma elliptical, radius short.

Abdomen thick and short. Male genital segment short; forceps as long as anal valve, slender, not much bowed outward, tip slightly enlarged and provided with a short, downwardly and inwardly directed point. Anal valve slender, apical third inclined caudad and tubular in shape. Female genital segment longer than abdomen, much narrower and acuminate, dorsal valve a little longer than ventral and both acutely pointed.

TENIMBER ISLANDS, Larat (*Muir*), 1 female. BORNEO, Sandakan (*Baker*), 1 male. SOUTHERN CHINA, Macao (*Muir*), 1 female. HAWAII, Oahu (*A. Koebele*), 1 imperfect specimen apparently of this species. The last was no doubt an immigrant, perhaps taken on some recently imported plant. It appears not to have become established on this island as it has not been again taken in subsequent collecting during many years.

The male specimen differs from the others in being darker colored and in having the antennæ nearly as long as width of head including the eyes, the basal tarsus of hind legs a little longer, and the cubital petiole (M + Cu) longer than the stem of the cubital vein, while in the females it is shorter. Whether or not these are specific differences can scarcely be determined until examples of both sexes from each locality are available for study.

This insect is somewhat suggestive of *Apsylla cistellata*, an Indian species, but seems to be closer to *Pauropsylla* than to *Apsylla*.

**Pauropsylla udei** Rübsaamen.

*Pauropsylla udei* RÜBSAAMEN, Ent. Nachrichten 25 (1899) 262–266.
*Pauropsylla bakeri* CRAWFORD, Philip. Journ. Sci. § D 10 (1915) 258.

Length of body, 2 millimeters; length of forewing, 2.6; length of antennæ, 1. General color dark reddish to chocolate brown; antennæ, legs, ventral portion of genæ, and genital segment orange yellow or paler; eyes pale; wings clear. Body robust.

Head short, deflexed, not as broad as thorax; vertex reticulately marked, elevated at posterior ocelli, extending forward between antennal bases and covering frons, inclosing anterior ocellus so that latter appears to be on vertex; frons scarcely visible; genæ swollen beneath antennal bases, without cones; clypeus small. Eyes rather large; front ocellus near posterior ocelli and visible from above. Antennæ a little longer than width of head, slender.

Thorax very broad, arched, robust, surface finely reticulately marked. Legs slender; hind legs long. Forewings very broad distally, more than half as broad as long, clear, very thin and delicate; veins slender; marginal cells small.

Abdomen moderately large. Male genital segment small; forceps simple, nearly one-half as wide (lateral view) as long, roundly acute at apex, arched; anal valve about one-half longer than forceps, simple, truncate at apex. Female genital segment about one-third as long as abdomen; valves about equal in length, acutely pointed at apex.

JAVA, Salatiga (*Leeuwen-Reijnvaan*), April 5, 1912, on *Ficus variegata* Blume, 6 males and 10 females. These psyllids produce galls resembling those of cecidomyid flies.

*Type locality.*—SUMATRA (*Ude*).

*Distribution.*—LUZON, Laguna Province, Mount Maquiling (*Baker*). JAVA, Salatiga (*Leeuwen-Reijnvaan*), April 5, 1912.

The type specimens were taken from galls on an undetermined plant said to belong to the family Rubiaceæ. The galls were subspherical, flattened below at attachment to leaf, covered with thickly set, unbranched spines and opening after the maturity of the insect into a flowerlike shape by the splitting and spreading of sectors of the spherical gall.

Pauropsylla triozoptera Crawford ('13: 296).

*Type locality.*—Los Baños, Luzon, Philippines.

Several specimens, apparently belonging to this species but with slightly larger and more broadly rounded wings and larger body with longer legs, were taken in JAVA, Sindaglaija (*Muir*), 1 male and 4 females. LUZON, Benguet, Baguio (*Baker*), 1 male, also larger than the type specimens.

The differences between the Philippine and Javanese forms are slight and such as might naturally develop from isolation and separation.

Pauropsylla triozoptera setifera Crawford ('13: 297).

By some error in the manuscript, this variety was incorrectly placed with *Pauropsylla triozoptera* instead of with *Paurocephala psylloptera*. The specimens bear the correct label, but somehow the transfer in the manuscript was made. This error should be corrected to read *Paurocephala psylloptera setifera* Crawford.

Pauropsylla tuberculata Crawford ('12: 430).

One mutilated specimen appears to be very close to this Indian species. One forewing is intact and most of the other, but

the head and abdomen including the genitalia are mutilated beyond recognition of characters. The venation is very similar but not quite identical. In the Indian species the medial vein forks just about midway between the cubitus and radius, while in the Pacific form the furcation of the media is nearer to the radius. It is possible that an unmutilated specimen would show other differences of specific value.

TENIMBER ISLANDS, Larat (*Muir*), 1 specimen of somewhat doubtful identity, tentatively included here.

### Genus LEPTYNOPTERA novum

Head deflexed, rather short, vertex broader than long, anterior angles typically produced over base of antennæ; genæ scarcely produced into cones; frons not covered by genæ. Antennæ rather short, second segment not barrel-shaped but produced distally on lower side. Thorax well arched. Legs long. Forewings membranous, broad distad, cubital petiole and first marginal cell both wanting, the cubitus reaching margin unforked. Hind wings nearly wanting, exceedingly short.

Type of the genus, *Leptynoptera sulfurea* sp. nov.

The position of this genus is a little doubtful, since it bears similarities to both *Trioza* and *Pauropsylla*. The shape of head, exposure of frons, shape of forewing, and some venational characters indicate a closer relationship to *Pauropsylla* than to *Trioza*. The absence of cubital petiole appears to be not exclusively a character of Triozinæ, as several unmistakable examples indicate. The unforked cubitus is a characteristic approached more or less closely by several species of *Pauropsylla*, suggesting that that vein of the forewing is subject to considerable variation. On the other hand, the same vein in Triozinæ appears to be more constant than many other characters of the body. The aborted hind wings are characteristic not only of this genus but also of a few species of *Trioza*, and to a lesser degree of species of *Pauropsylla* and several other specialized genera. There appears to be a more or less wide tendency in the entire family toward reduction of the hind wings in function, strength, and size.

**Leptynoptera sulfurea** sp. nov. Plate 1, figs. 5 and 6.

Length of body, 1.7 millimeters; forewing, 2.6. General color bright sulphur yellow, with four narrow, inconspicuous, brown stripes on mesonotum; abdominal tergites with white transverse bands; eyes pale whitish; legs pale, femora whitish; antennal segments 1 and 2 yellow, remainder whitish with three black

bands, one at end of segment 4, another at tip, and another midway between; forewings clear except brown in anterior basal cell.

Head not as brown as thorax, strongly declivous, with long, sparse pubescence; vertex a little more than half as long as broad, anterior portion bent downward, posterior ocelli elevated, with a rather deep foveal impression on each side of median line, anterior outer corners produced into a short, upturned epiphysis over each antennal base. Genæ a little swollen beneath antennal sockets, bulging slightly forward of vertex. Frons wholly visible, broadest at base; clypeus moderately small; rostrum short. Antennæ a little longer than width of head, banded black and white, second segment with one side of apex produced.

Thorax broad, strongly arched, sparsely clothed with long hairs, mesonotum very short, transverse; pseudonotum (behind metanotum) large, long, with a pair of slender, upturned, whitish horns between this and basal segment of abdomen. Legs long, hind tibiæ long, with a very small basal spur and short distal spines. Forewings somewhat rectangular, hyaline, veins narrow, pterostigma wanting, radius not straight, cubitus unforked. Hind wings reaching about to primary fork of basal vein, veins practically wanting.

Abdomen short (genitalia mutilated).

MOLUCCAS, Amboina (*Muir*), 1 example.

## Genus PAUROCEPHALA Crawford

*Key to the species.*

$a^1$. Forewing with pterostigma; vertex rounded forward and down; head strongly deflexed.

$b^1$. Metascutellum with a conical, usually acutely pointed, epiphysis dorsad; female genital segment usually deflexed at right angles to abdomen.

$c^1$. Antennæ distinctly longer than width of head; posterior ocelli prominently elevated; tip of female genitalia straight.

$d^1$. Body surface and wing veins not hairy or with only very inconspicuous pubescence. (Philippines, Ceylon, and Malay Archipelago.) .................... P. psylloptera Crawford ('13: 294).

$d^2$. Body surface and wing veins conspicously hairy. (Philippines, Fiji, and Singapore.).... P. psylloptera setifera Crawford ('13: 297).

$c^2$. Antennæ not longer than width of head, usually not as long, posterior ocelli not much elevated; tip of female genitalia curved outward.

$d^1$. Antennæ about as long as width of head with eyes; forewing with three dark spots on costal margin; insect very small. (Philippines.) ........................ P. minuta sp. nov.

*d*[4]. Antennæ shorter, about as long as head between eyes; forewings with five or six marginal spots; insect a little larger. (Philippines.) .............................. P. brevicephala Crawford ('17: 163).

*b*[2]. Metascutellum without conical epiphysis; female genital segment typically horizontal.

*c*[1]. Frons large and prominent, not covered by genæ; forewings converging in distal half to apex; genæ swollen subconically beneath antennal bases.

*d*[1]. Forewings narrowly rounded at apex; hyaline; frons very large. (Southern Mexico.) ............... P. magnifrons Crawford ('14: 42).

*d*[2]. Forewings subacute at apex, not hyaline and often nearly opaque; frons smaller. (Malay Archipelago.) ........ P. conigera sp. nov.

*c*[2]. Frons smaller, mostly covered by genæ; forewings not converging, broadly rounded; genæ scarcely swollen beneath antennal bases. (Southeastern United States.)
P. ilicis (Ashmead) Crawford ('14: 43).

*a*[2]. Forewing without pterostigma; vertex more flattened and head less deflexed.

*b*[1]. Forewings conspicuously maculated; radius and medial veins sinuate. (Singapore.) .......................................................... P. maculata sp. nov.

*b*[2]. Forewings not maculated, clear; veins not sinuate. (Philippines.)
P. orientalis Crawford ('15: 261).

**Paurocephala psylloptera** Crawford.

This appears to be a common species, widely distributed in the South Pacific regions. Since additional material has come to hand it seems necessary to supplement the original description which was drawn up from six specimens. The color of the male is not uniformly darker than the female; both sexes are usually very dark chocolate brown to dull black; lighter forms seem to be less matured, the color deepening with age; vertex and thoracic dorsum sometimes with orange yellow streaks but more commonly uniformly dark, antennæ usually as dark as vertex; legs often lighter in color or even yellowish. Body surface often not hairy; vertex and thoracic dorsum finely, reticulately marked. The beak is moderately long and the mandibular setæ sometimes exserted to a length of 1 millimeter or less. The hind tibiæ have a row of about seven black spines on outside, several spines at apex and are more or less hirsute. The metacoxal spurs are long and slender. Pterostigma of forewings usually dark colored, veins black.

In the Philippine Islands this species has been collected in LUZON, Los Baños (*Baker*), on *Ficus ulmifolia;* and on Mount Maquiling (*Baker*). CEYLON, Peradeniya (*Rutherford*), on *Ficus hispida* and *Ficus asperrima.* Additional specimens are now before me from TENIMBER ISLANDS, Larat (*Muir*), December, 1907, 18 males and 18 females.

**Paurocephala psylloptera setifera** Crawford.

*Pauropsylla triozoptera setifera* CRAWFORD, Philip. Journ. Sci. § D 8 (1913) 297.

Several specimens from Fiji Islands appear to belong to this variety. The color is uniformly a little darker than the average of the Philippine forms, but the markings on vertex and notum are similar and the antennæ are similarly colored, darker at tips of segments 3 to 8. The body surface is a little less hirsute than in the Philippine forms. By a mechanical error this variety was originally placed with the wrong species.

FIJI ISLANDS (*Muir*), 2 males and 3 females, 1905. SINGAPORE (*Baker*), 1 male. The specimen from Singapore differs from the type of the variety in being orange yellow with some darker streaks on notum. The body surface and wing veins are less hirsute, but the male genitalia are quite similar.

**Paurocephala brevicephala** Crawford.

*Pauropsylla brevicephala* CRAWFORD, Philip. Journ. Sci. § D 10 (1917) 163, pl. 1, fig. 11.

This Philippine species was misplaced in the genus *Pauropsylla*. The wing venation, form of vertex and presence of the metascutellum epiphysis point to its close affinity with species of *Paurocephala*. A few additions to the original description are here made.

Vertex not prominently elevated at posterior ocelli, without foveal impressions. Surface of vertex and dorsum finely reticulately marked. Metascutellum produced upward into a thick epiphysis with a very small, acute point. Hind legs longer than others, but relatively shorter than in some other species of the genus. Female genital segment turned downward, with tip of dorsal valve curved outward, acute. The shortness of the antennæ is an unusual character in this genus.

MINDANAO, Davao (*Baker*), 3 females.

**Paurocephala minuta** sp. nov. Plate I, fig. 8.

Length of body, female, 0.9 millimeter; length of forewing, 1.4. General color brown to dark brown, with legs, venter, and antennæ lighter or pale; a whitish or pale spot on thorax at base of each forewing. Body small.

Resembling *P. psylloptera* in many characteristics, and apparently closely related to that species. Vertex relatively broader and with foveal impressions and postocellar elevations less prominent. Antennæ short, scarcely as long as width of

head. Thorax well arched, broad; metascutellum with a large, blunt epiphysis; legs short; hind tibiæ relatively shorter than in related species, with fewer spines; forewings small, similar in shape to related species, but pterostigma relatively longer and narrower and less-dark colored; three dark spots on costal margin, one at base of pterostigma, another at tip of same, and a third at tip of radius.

Female genital segment deflexed but shorter than in *P. psylloptera*, tip of both valves very acute and flexed outward.

LUZON, Laguna Province, Los Baños (*Baker*), 1 female.

**Paurocephala maculata** sp. nov. Plate I, fig. 9.

Length of body, 1.2 millimeters; length of forewing, 1.4. General color reddish brown, more or less glossy, smooth, venter of thorax and abdomen tawny, femora orange, tibiæ darker; antennal segments 1 and 2 reddish, 3 to 8 white or pale, 9 and 10 black or brown; forewings beautifully maculated, mostly brownish with several large clear areas and numerous, minute, dark spots in the brown.

Head short, nearly as broad as thorax, deflexed, vertex smooth and shining, without prominent depressions or elevations, rounded downward in front sharply, anterior ocellus visible from front only; frons visible from in front and below, small; genæ swollen beneath antennal bases, making an emargination in which the clypeus is visible. Antennæ a little longer than width of head, segment divisions not distinct.

Thorax arched, broad, dorsal surface smooth and glossy except a large elevated callus on each side of dorsulum (mesoscutum) rough and lighter red in color; metascutellum with a long, low elevation along median line. Legs short. Forewings a little longer than body, broadly rounded at apex, conspicuously maculated; radius and media sinuate; pterostigma wanting, first marginal cell long and narrow.

Female genital segment moderately large, not deflexed, dorsal valve a little longer than ventral, acutely pointed and tip flexed outward.

SINGAPORE (*Baker*), 1 female.

This species is somewhat different from the type of *Paurocephala* (in the absence of pterostigma and the sinuate veins), but provisionally, at least, it is included in this genus.

**Paurocephala conigera** sp. nov. Plate I, fig. 10.

Length of body, 2.7 millimeters; forewing, 4. General color orange to yellowish brown or brown; venter and legs a little

lighter in color; antennæ dark distad; forewings semitransparent, usually brownish or sometimes brown and opaque.

Head strongly declivous, fully as broad as thorax. Vertex a little more than half as long as broad, subperpendicular to axis of body, with a shallow sulcus across posterior portion, surface somewhat convex. Frons visible in front, with large ocellus. Genæ swollen beneath antennal bases into subconical processes very broad at base, subacutely pointed and about one-third as long as vertex. Antennæ a little less than twice as long as width of head, slender.

Thorax not strongly arched. Legs rather short, hind tibiæ with a small spur at base. Forewings long and narrow, subacute at apex, membrane thick, semitransparent or often opaque because of the brown color.

Abdomen long. Male forceps slender, little more than half as long as anal valve, acutely pointed; anal valve long and rather slender, tapering from base to subacute apex. Female genital segment about half as long as abdomen, dorsal valve with a large, rounded convexity dorsad, acutely pointed, a little longer than ventral valve.

MOLUCCAS, Amboina (*Muir*), 1 male and 3 females.

This resembles *P. magnifrons*, a tropical American species, more closely than other species of this genus. Quite possibly these two species should be referred to a distinct genus.

### Genus **HETERONEURA** novum

Head somewhat as in *Pauropsylla*, much deflexed and short; vertex roundly convex; frons inferior, with anterior ocellus visible only from in front; genæ small, not much swollen, cones wanting; eyes rather small; beak short; antennæ as long as width of head or longer.

Thorax well arched; legs short, front tibiæ flattened, thin and foliaceous; hind tibiæ with a tooth near apex; metacoxal spurs short. Forewings coriaceous, opaque, broad; marginal cells long and narrow as in *Paurocephala;* second marginal cell flexed toward costal margin; radius contorted; pterostigma closed.

Type of the genus, *Heteroneura oeeanica* sp. nov.

This genus appears to belong to the subfamily Pauropsyllinæ, but differs from other genera of this subfamily in the coriaceous forewings, the much contorted radius, and the foliaceous front tibiæ.

**Heteroneura oceanica** sp. nov. Plate I, fig. 11.

Length of body, 1.8 millimeters; length of forewing, 2; length of antennæ, 1.2. General color dark brown; meso- and meta-

scutellum dirty white or yellowish; antennal segments 3 to 8 dark at apex and light basally, 9 and 10 black; forewings opaque, brown, small area at base and another at tip whitish, veins tawny; between the veins rows of many, small, light-colored patches, giving a very striking and characteristic appearance to the wings. Body surface sparsely covered with rather long hairs.

Head short, not as broad as thorax, much deflexed, hairy; vertex roundly convex, without foveal impressions, scarcely elevated at posterior ocelli; frons scarcely visible; front ocellus not visible from above, close to clypeus; genæ small, somewhat swollen beneath each antennal insertion, without cones. Antennæ twice as long as width of head, slender.

Thorax broad, robust, hairy. Legs rather short; front and middle pairs of tibiæ conspicuously flattened and somewhat foliaceous and front femora somewhat flattened in distal half; hind tibiæ with a large, prominent tooth near apex. Forewings coriaceous, not flat but somewhat convex, broadly rounded at apex; venation very singular and characteristic; pterostigma shaped like a marginal cell; radius much contorted, second marginal cell long and narrow and parallel with posterior and apical margins of wing.

Abdomen about as long as thorax. Female genital segment short, about one-fourth as long as abdomen; dorsal valve a little longer than ventral, both slender and acute at tip, dorsal valve with an acute epiphysis at apex.

SINGAPORE (*Baker*), 1 female. LUZON, Bataan Province, Mount Limay (*Baker*), 1 female. BASILAN (*Baker*), 1 female.

## Genus HETEROPSYLLA Crawford

This American genus, comprising seven described species, is a well-marked group. One species apparently abundant in the South Pacific is closer to this genus than any other. Although it differs in some important characteristics from the American species, it is nevertheless included herein for the present.

### Heteropsylla longicornis sp. nov. Plate 1, fig. 12.

Length of body, 2 millimeters; length of forewing, 2.1; length of antennæ, 4. General color light to dark reddish brown; tibiæ, tarsi, metapleuræ, and a small area beneath each eye pale; several streaks on thoracic dorsum white or pale; two longitudinal rows of white spots on each side of abdomen. Body surface pubescent.

Head nearly as broad as thorax, short, deflexed; vertex broad,

triangular on each side of median line with long side next to eye, prominently elevated at posterior ocelli, with median suture conspicuous and convex between antennal sockets and median suture, with an elongate sulcus distally on each side of median line; anterior ocellus scarcely visible from above; frons mostly covered by genæ; genæ very expansive, but not swollen, continuing to clypeus in nearly the same plane with distal portion of vertex. Clypeus moderately large, beak very long and prominent. Eyes very large. Antennæ one and a half to two times as long as body without wings, very slender and threadlike, darker apically.

Thorax broad, well arched; propleurites covered by recessive eyes, metascutellum elevated into a large, prominent epiphysis. Legs large, hairy; hind tibiæ with spur at base and several spines at apex; basal tarsus of third leg with two black spines at apex. Forewings membranous, clear, with several (usually six) black or brown spots along posterior and apical margins; veins setiferous.

Abdomen somewhat laterally compressed dorsad, and more or less triangular in transverse section, sharply angled above; each segment with a dense fringe of hairs on posterior margin. Male genital segment not large; forceps not quite as long as anal valve, nearly as broad; anal valve long and slender, inclined toward forceps, truncate at apex. Female genital segment about half as long as abdomen, both valves subequal in length, acute, hairy.

TENIMBER ISLANDS, Larat (*Muir*), December, 1907, 57 males and females. MOLUCCAS, Amboina (*Muir*), January, 1908, 1 male and 12 females.

This differs from the other species of the genus in the larger size, longer antennæ, armed hind tibiæ, and epiphysis on metascutellum. The other species are American. An imperfectly preserved specimen from the Philippines seems to belong to this genus.

**Phacopteron lentiginosum** Buckton.

*Phacopteron lentiginosum* CRAWFORD, Rec. Indian Mus. 7 (1912) 420, pl. 33, figs. A, B, F; pl. 35, fig. A.

*Nymph.*—The nymph of this species is very large and robust, not flattened as in most psyllids but more cylindrical or saccate, the shape characteristic of most gall-forming species. Head very short, much narrower than thorax; eyes not bulging, small; antennæ about as long as width of head, stout; clypeus large and prominent. Thorax nearly as broad as abdomen, legs short

and stout. Abdomen large, the broadest part of body broadly rounded caudad.

Four adult specimens and three nymphs of this large and striking psyllid are before me, collected in Pollibetta, Coorg, India, on May 27, 1914, from galls on leaves of an unidentified tree.

CARSIDARINÆ

This subfamily has much larger representation in tropical countries, only a few species being found as far north as the southern United States. Previous to 1911 so few representatives of this subfamily had been discovered and examined that those few were assigned positions in genera variously related to the other Psyllidæ; but when an increasingly large number of forms from many tropical localities began to come to hand, it became apparent that a comparatively large tropical fauna of this type existed.

As our knowledge of this group advances we shall no doubt have to recast our taxonomic conceptions. One of the most striking peculiarities of the representatives first examined was the deeply cleft head, with the thickened antennæ enhancing the cleft appearance, and the absence of genal cones. Examination of more species of this subfamily, however, has shown that these characteristics are not to be found throughout the subfamily, though the genal cones usually are absent. The body always has a characteristic elongate form, and the wings have a peculiar venation; though this latter peculiarity is one not easily explained nor easily appreciated by one unfamiliar with the group.

As the tropical countries of the world are more carefully explored for their insect life, it is probable that many new and perhaps quite different types of this subfamily will be brought to light, necessitating changes in our taxonomic disposition of these very interesting little creatures.

The following subfamily description is intended to supersede the previous definitions of this group:

Body typically elongate, often slender. Head usually cleft in front, vertex more or less concave on front margin and genæ swollen out forward beyond vertex at each antennal base, and the latter often swollen and increasing the birostrate appearance of the head, but in at least two genera, *Nesiope* and *Tenaphalara*, head not birostrate. Genal cones usually wanting or very small and inconspicuous. Beak very long. Eyes hemispherical, usually not at all recessive. Antennæ usually long, often thick-

ened and sometimes very hairy. Thorax not strongly arched. Hind tibiæ usually with a spur at base and spines at apex; basal tarsus of hind legs usually with one black claw (two in *Homotoma*, but the relationships of this genus are not clear). Forewings always membranous and hyaline, usually more or less acutely pointed, often with a veinlike callus or two connecting veins distad. There is a scarcely definable, characteristic manner of branching of medial and cubital veins.

Although I have seen no representatives of certain Autralian genera, the illustrations and descriptions of these point to an affinity with Carsidarinæ so clearly that they have been included here, tentatively. *Homotoma* is an old genus and still of very doubtful relationship. The presence of two claws on the basal tarsus of the hind legs is distinctly a characteristic—and apparently an important one—of Psyllinæ and not of Carsidarinæ. The genæ, also, often are produced into distinct cones. It is possible that the genus should be referred to another subfamily, but for the present at least it may be retained here.

*Key to the genera.*

$a^1$. Cubitus and media with common stalk (cubital petiole).
$b^1$. Antennæ thick throughout, not longer than body to tip of abdomen.
$c^1$. Antennæ thickly hirsute and often carinate; genæ usually with conical processes directed downward on each side of clypeus.
Homotoma Guerin.
$c^2$. Antennæ not hirsute, nor carinate, but terete; genæ not produced into cones.......... Epicarsa Crawford.
$b^2$. Antennæ slender at least beyond third segment, usually distinctly longer than body (except in *Macrohomotoma*), not hirsute.
$c^1$. Head birostrate in appearance, by the projection forward of genæ on each side of midline and attachment of antennæ at end of projecting genæ.
$d^1$. Outer anterior angles of vertex elevated above genæ, more or less hornlike; insect usually very large.
$e^1$. Female genitalia with ventral valve nearly as long as dorsal, latter without thick fringe of hairs; vertex produced into a large horn over each antennal socket; hind tibiæ without basal spur, with very large spines at apex; first antennal segment very long; forewing with marginal cells nearly equal in size.......... Dynopsylla Crawford.
$e^2$. Female genitalia with ventral valve very short, dorsal valve many times larger and very thickly fringed with stiff hairs along ventral margin, vertex sharply angled but not produced into horns in front; hind tibiæ with basal spur; first marginal cell of forewing much smaller than second.
Thysanogyna g. nov.
$d^2$. Vertex not as above.
$e^1$. Forewings with pterostigma, hind tibiæ usually with basal spur; antennæ very long and slender.

$f^1$. Transverse callus connecting radius and media; hind tibiæ with spur at base; pterostigma open or closed.
**Carsidara Walker.**

$f^2$. Transverse callus in forewing wanting.. **Mycopsylla Froggatt.**

$e^2$. Forewings without pterostigma; hind tibiæ with or without basal spur.

$f^1$. Antennæ long and very slender.

$g^1$. Vertex produced in front into two long points (not genal cones); hind tibiæ without basal spur.
**Geljerolyma Froggatt.**

$g^2$. Vertex not so produced, but more or less deeply cleft in front; hind tibiæ with basal spur.
**Tyora Walker** (*Mesohomotoma* Kuwayama).

$f^2$. Antennæ long but not slender, vertex deeply cleft in front.
**Freysuila Aleman.**

$f^3$. Antennæ very short and slender; vertex not deeply cleft in front ............................................ **Macrohomotoma Kuwayama.**

$c^2$. Head not birostrate, vertex more or less quadrate.

$d^1$. Margins of vertex turned up in a narrow rim; female genital segment long and acuminate.............................. **Nesiope Kirkaldy.**

$d^2$. Margins of vertex not turned up, but vertex usually inclined roundly forward and downward; female genital segment with dorsal valve constricted subapically.... **Tenaphalara Kuwayama.**

$a^2$. Cubitus and media without stalk (triozine).

$b^1$. Antennæ thick and hairy; genæ sometimes swollen beneath into more or less conical processes........................................... **Bactericera Puton.**

$b^2$. Antennæ slender and not hairy; genæ without cones beneath.

$c^1$. Head more or less birostrate (as in *Carsidara*).... **Rhinopsylla Riley.**

$c^2$. Head not at all birostrate; vertex nearly quadrate, declivous.
**Tenaphalara triozipennis Crawford.**

## Genus THYSANOGYNA novum

Head cleft in front as in other genera of this subfamily; genal cones almost or quite wanting; vertex more or less quadrate, concave, outer anterior corners sharply angled and elevated, with anterior ocellus in front at notch of frontal cleft; antennæ slender except segments 1 and 2, not excessively long; beak moderately long.

Thorax large; legs large; hind tibiæ with spur at base and large spines at apex; basal tarsus of hind legs with one black spine at apex. Forewings large, with closed pterostigma, short radius and indistinct pseudovein between radius and media; first marginal cell much smaller than second.

Abdomen large; female genitalia somewhat dissimilar from other genera; dorsal valve large, with a dense fringe of hairs on lower margin; ventral valve very small and often retracted into preceding abdominal segment; ovipositor large, broadly truncate, edges fluted.

Type of the genus, *Thysanogyna minor* Crawford.

This species was first described from a single male as belonging to *Dynopsylla*, but some characters were noted in which the species did not conform to the generic type. Subsequently many other specimens of this species have come to hand and among them females. The genitalia of the female at once show a marked difference not only from *Dynopsylla* but from most other genera. This species, therefore, is designated the type of a new genus, which appears to be related to other genera of Carsidarinæ. Since the first description did not include the female and was somewhat inadequate in a few other respects, a more detailed specific description is given herewith to replace the other.

**Thysanogyna minor** Crawford. Plate II, figs. 2 and 4.

*Dynopsylla minor* CRAWFORD, Philip. Journ. Sci. § D 12 (1917) 263.

Length of body, 2.7 millimeters; length of forewing, 5; greatest width, 2.3. General color light brown with darker brown streaks on thoracic dorsum or the color may be dark brown with lighter streaks; antennæ with apical third or half of segments 3 to 8 and all of 9 and 10 black. Body surface more or less covered with white flocculent excretion. Insect large and robust.

Head about as broad as prothorax, but mesothorax considerably broader, not much deflexed, cleft in front. Vertex a little more than half as long as broad, deeply concave, the median suture prominent, and the two halves nearly quadrate, the outer anterior corner acute and upstanding, giving the appearance of a horn (somewhat as in *Dynopsylla*); anterior margin of vertex somewhat emarginate, the protruding genæ at base of antennæ much emphasizing this emargination. Anterior ocellus in front at base of cleft; frons visible as a small and narrow sclerite between genæ and below front ocellus. Genæ very large, protruding in front to form antennal bases, beneath the head and just in front of labrum produced into a pair of very small wartlike cones. Labrum not large; beak about as long as third antennal segment. Antennæ moderately long and slender, not as long as body but usually as long as head and thorax or a little longer.

Thorax very large, well arched and broad, sparsely hairy. Pronotum large; mesonotum very large; metanotum with a pair of short blunt horns or epiphyses caudad. Legs long and large; hind tibiæ with spur at base and several long fingerlike spines at apex; tarsi long. Forewings large and long, narrowly rounded at apex, transparent, with four small brown spots along poste-

rior margin and one in pterostigma; an indistinct pseudovein connecting radius and media, as in *Carsidara*.

Abdomen large. Male anal valve a little longer than forceps, broadest at middle; forceps somewhat fusiform, thick at middle, apically tapering to a narrow and truncate end. Female genital segment large; dorsal valve very large, with a small, curved, acute epiphysis caudad, and a large anal opening dorsad; the lower margin densely fringed with slender hairs, as a brush. Ventral valve very small and retracted more or less completely into preceding abdominal sclerite with an acute epiphysis at apex. Ovipositor large, very broadly truncate at apex, apparently permanently exserted, margin fluted.

LUZON, Laguna Province, Mount Maquiling (*Baker*), 1 female: Tayabas Province, Malinao (*Baker*), 2 females. TENIMBER ISLANDS, Larat (*Muir*), December, 1917, 5 males and 13 females.

*Type locality*.—LUZON, Laguna Province, Los Baños.

The Larat specimens very closely resemble those from the Philippines except in some very minor color characters and the following two wing characters: Forewing of Larat specimens a little less acute at apex, and radius shorter; in Philippine specimens the radius joins the margin at a point as far from tip of pterostigma as the length of latter; in Larat specimens the length of pterostigma is nearly twice the length from tip of radius to tip of pterostigma. This probably indicates the incipiency of another species.

## Genus TYORA Walker

This genus is very close to *Carsidara*, differing chiefly in the absence of pterostigma in the forewing. Froggatt's *Tyora sterculiæ*, however, does possess the pterostigma. I am inclined to believe that *Tyora* should be merged with *Carsidara*, but until more material is available for comparison I am unwilling to make this change. *Tyora indica*, described below, is evidently very closely related to *T. hibisci* Froggatt but has no claw nor spine at apex of hind femora said to be present in both the Australian species of this genus.

*Mesohomotoma* Kuwayama is apparently very close to *Tyora*, differing in no essential character whatever, so far as I can discover, from Kuwayama's description. However, until I have examined a representative of the Japanese genus, I am loath to make any alteration.

Tyora indica sp. nov. Plate II, fig. 1.

Length of body, male, 2.4 millimeters; female, 3.3; length of forewing, male, 3.5; female, 4.7; length of antennæ, 1.9. Gen-

eral color orange yellow to yellowish green, dorsum of thorax sometimes with paler streaks or often white stripes in male; antennal segments 4 to 8 black at tip, 9 and 10 all black; wings clear with several small dark spots along margins. Body surface often covered with white flocculent material.

Head small, little broader than prothorax, not deflexed, deeply cleft in front, vertex with edges and median line elevated into a narrow rim with two deep fossæ extending from posterior margin slightly divergently toward antennal bases; in the male the lateral ridges and ridge on each side of median suture are often whitish; anterior outer angle of vertex acute and forming a small hornlike epiphysis over eye; anterior ocellus at front margin of vertex, a little above apex of frontal cleft and visible from above. Genæ not swollen into cones beneath, but projecting forward at antennal bases forming frontal cleft. Frons very narrow, scarcely visible between genæ. Antennæ a little more than half as long as body, slender. Beak moderately long.

Thorax not much arched, not broad. Legs rather short and slender; hind tibiæ with a small spur at base and several black spines at apex; basal tarsus of hind legs with one black spine at apex. Forewings hyaline, long, about two and three-fourths times as long as broad, with pseudovein connecting short radius and media; pterostigma wanting.

Male abdomen slender; genital segment small; forceps very slender, arched, acutely pointed; anal valve shorter than forceps, relatively very broad, expanded laterally. Female abdomen larger, broader; genital segment nearly as long as rest of abdomen; dorsal valve bulging upward and hirsute midway and abruptly constricted in apical third to an acute point; ventral valve tapering to an acute point, nearly as long as dorsal.

MOLUCCAS, Amboina (*Muir*), January, 1908, 5 males and 6 females. INDIA, Mercara, Coorg (*Y. R. Rao*), May 24, 1917, 3 females.

This species is very close to *Tyora hibisci* Froggatt, differing in some color characters and in the genitalia of both sexes. *Mesohomotoma camphoræ* Kuwayama is very similar to this species and apparently is not generically distinct.

### Genus NESIOPE Kirkaldy

*Nesiope* KIRKALDY, Proc. Linn. Soc. N. S. W. 33 (1908) 389.
*Carsidaroida* CRAWFORD, Philip. Journ. Sci. § D 12 (1917), 165.

*Nesiope* and *Tenaphalara* differ sharply from the remainder of the subfamily in the shape of the head, which in these two genera is not at all cleft as it is in the others. Notwitstanding

this disparity there is undoubtedly a close relationship between these two and the others, as indicated by similarity of venational and certain other body characters, as the presence of but one claw on the basal tarsus of hind legs.

The close similarity between Kirkaldy's *Nesiope* and my *Carsidaroida* did not appear until the latter had been published, wherefore it becomes necessary to merge my genus with the other. The differences between the species are brought out in the following key:

*Key to the species.*

a¹. Thoracic dorsum conspicuously striped with black (or brown) and yellowish (or orange) longitudinal bands; length of insect more than 5 millimeters.

b¹. Forewings scarcely spotted, more or less fumate; insect large, usually over 7 millimeters long. (Philippines, Singapore, and Amboina.) .................................... N. heterocephala Crawford ('17: 165).

b². Forewings conspicuously spotted in apical half with many small brown and large black spots. Insect about 5 millimeters long. (Larat and Java.) ....... ....... N. heterocephala intermedia var. nov.

a². Thoracic dorsum not as above, but with "a central pale line down dorsulum and mesonotum very narrowly bordered with black; sides of mesonotum broadly ferruginous, with two pale, curved, very narrow lines;" forewings spotted with brown in apical half. (Fiji.) N. ornata Kirkaldy ('08: 389).

**Nesiope heterocephala** Crawford ('17: 165).

CELEBES and AMBOINA (*Muir*), 5 males and 3 females. SINGAPORE (*Baker*), 1 pair.

*Type locality.*—LUZON, Benguet, Baguio (*Baker*).

**Nesiope heterocephala intermedia** var. nov.

Similar to the species, except body of both sexes distinctly smaller and forewings with apical third or half dotted with numerous brown spots and several elongate, black spots. In some individuals of the species there is a slight spotting as in the variety, but this is not nearly so conspicuous. Genitalia of both sexes similar to the species but smaller. The maculation in this variety appears to be quite distinct from that of *N. ornata*, judging from Kirkaldy's description and figure of the latter.

TENIMBER ISLANDS, Larat (*Muir*), December, 1907, 4 males and 8 females. JAVA, Buitenzorg (*Muir*), 1 male.

## Genus HOMOTOMA Guerin

Although this genus bears unmistakable resemblance to other genera of Carsidarinæ, its relationship is not wholly clear yet.

I attach a good deal of importance, taxonomically, to the clawlike spines on the basal tarsus of the hind legs. In Psyllinæ there are two such "claws," in Triozinæ none, while in Carsidarinæ there is one "claw." In *Homotoma*, however, there are usually two and in *Mycopsylla* there appear to be two. In some other respects, also, this is somewhat of an aberrant genus, but it is retained in this subfamily, for the present at least.

*Key to the species.*

$a^1$. First marginal cell much smaller than second or wanting; radius and media quite or nearly contiguous for a greater or less length; pterostigma wanting.

$b^1$. Medial vein contiguous with radius for about one-half length of latter, leaving an open cell between them on costal margin.

$c^1$. First marginal cell present; a black band following radius to margin and another following cubitus. (Formosa.)
**H. radiatum** Kuwayama ('08: 181).

$c^2$. First marginal cell wanting; the two black bands wanting, but radial vein prominently black. (Bengal.)
**H. distincta** Crawford ('12: 433).

$b^2$. Medial vein contiguous with radius for nearly or quite the entire length of latter, leaving no cell or only a very small one between them; a black band following radius and media, and a second one following cubitus; first marginal cell present but small.

$c^1$. Insect large, 6 millimeters long to tip of folded wings; antennæ terete, without carinæ; costal margin of forewing roundly arched, wing nearly half as broad as long. (Philippines and Straits Settlements.) **H. bakeri** Crawford ('15: 263).

$c^2$. Insect smaller, about 3 millimeters long to tip of folded wings; antennæ carinate; costal margin of forewing much less arched, wing about one-third as broad as long. (Philippines.)
**H. bilineata** Crawford ('17: 164).

$a^2$. First marginal cell nearly as large as second; radius and media not contiguous; pterostigma present; wing veins margined with black; antennæ carinate. (Philippines.) **H. pacifica** Crawford ('15: 262).

**Homotoma bakeri** Crawford ('15: 263).

A single male has been taken by C. F. Baker on Penang Island, Straits Settlements. As the original description of this species was drawn up from a female example, the male genitalia are here described.

*Male.*—Forceps as long as anal valve or longer, basal half with a carina on outer face, distal half enlarged, somewhat spearhead-shaped with tip bluntly rounded. Anal valve very slender in distal half, base broader.

Hind wings in both sexes very small and almost nerveless.

## Genus TENAPHALARA Kuwayama

*Tenaphalara* Kuwayama, Trans. Sapporo Nat. Hist. Soc. 2 (1908) 154.
*Strogylocephala* Crawford, Philip. Journ. Sci. § D 12 (1917) 166.

Body elongate, slender; head not much deflexed, nearly or quite as broad as thorax; vertex more or less rounded forward and downward, with anterior ocellus at front end of head and antennæ inserted at end on each side of front ocellus; genæ not produced into cones, slightly swollen beneath antennal sockets, usually not wholly covering frons, antennæ slender; eyes hemispherical, not recessive.

Thorax slender, not arched; legs slender, often rather long. Forewings long and narrow, more or less acutely pointed; venation of Carsidarinæ type, with two pseudoveins or calluses; pterostigma present. Abdomen long and slender.

Type of the genus, *Tenaphalara acutipennis* Kuwayama.

This is rather an anomalous genus, suggestive of *Aphalara* and also *Pauropsylla* in the head shape, and of Carsidarinæ in wing venation, tarsi, and eyes. Kuwayama placed the genus at the end of his subfamily Aphalarinæ, but the majority of the characters point rather to an affinity with Carsidarinæ. Although the head is not cleft in front, as in *Carsidara*, nevertheless this genus is now referred to the subfamily Carsidarinæ. This is a tropical subfamily and many forms doubtless remain undiscovered. *Nesiope* appears to be intermediate between *Carsidara* with its deeply cleft head and *Tenaphalara* with its head not at all cleft in front.

*Key to the species.*

$a^1$. Vertex smooth and uniformly rounded forward and down to genæ, with antennæ slender and well separated at base.

$b^1$. Forewings with a longitudinal brown vitta; vertex very abruptly descending; insect dark colored, small, less than 3 millimeters long to tip of folded wings. (Philippines.)
T. fascipennis Crawford ('17: 167).

$b^2$. Forewings clear, without vitta; vertex less abruptly descending; insect greenish yellow, larger, at least 4 millimeters long to tip of folded wings. (Formosa, Philippines, and Bengal.)
T. acutipennis Kuwayama ('08: 155).

$a^2$. Vertex not smooth nor uniformly rounded forward and downward to genæ.

$b^1$. Vertex with a prominent epiphysis just behind each antennal base; posterior ocelli elevated; antennæ approximate at base.

$c^1$. Forewings with pterostigma; third antennal segment distinctly thicker than succeeding segments. (Malay Peninsula.)
T. malayensis sp. nov.

$c^2$. Forewings without pterostigma; third antennal segment not thickened. (Borneo.) ........................ **T. juliana sp. nov.**

$b^3$. Vertex without epiphyses, with longitudinal dark stripes; ocelli not elevated; antennæ slender, not approximate at base.

$c^1$. Pseudo (cross) veins present in forewings; radius and mediocubitus not forking from basal vein at same point; vertex flattish, with four longitudinal dark stripes. (Malay Peninsula.) **T. striata sp. nov.**

$c^2$. Pseudo (cross) veins wanting; radius, media, and cubitus all forking from basal vein at the same point (as in Triozinæ); vertex more rounded, with three black stripes. (Malay Peninsula.) **T. triozipennis sp. nov.**

**Tenaphalara acutipennis** Kuwayama.

*Tenaphalara acutipennis* KUWAYAMA, Trans. Sapporo Nat. Hist. Soc. 2 (1908) 155.

*Tenaphalara elongata* CRAWFORD, Rec. Indian Mus. 7 (1912) 432, pl. 34, figs. M, N, P, Q; pl. 35, fig. O.

Length of body, 2.5 to 2.9 millimeters; forewing, 2.8 to 3.3. General color greenish yellow; dorsum sometimes with whitish longitudinal streaks; eyes brown; antennæ black at tip. Body long and slender.

Head not deflexed, not quite as broad as thorax, anterior end broadly rounded both horizontally and dorsoventrally. Vertex quadrate, a very little longer than broad, inclined downward somewhat roundly, without prominent foveal depressions. Genæ slightly swollen beneath antennal bases but not meeting over frons; frons visible between genæ; anterior ocellus at front end of head, at end of frons. Antennæ about two and one-half times as long as width of head, slender.

Thorax narrow, not arched, pronotum long; dorsulum short. Legs slender, rather long; hind tibiæ with spur at base and three large, black spines at apex. Forewings long and slender, three times as long as broad, hyaline, transparent, sometimes slightly flavous, acute at apex, with pseudovein between radius and radial sector and another between radial sector and media.

Abdomen long and slender, tapering to narrow apex. Male forceps nearly as long as anal valve, slender, arched, roundly acute at apex; anal valve broadest in basal third, tapering to apex. Female genital segment about one-fourth as long as abdomen; dorsal valve longer than ventral, somewhat enlarged at tip, ventral valve acute.

LUZON, Laguna Province, Los Baños (*Baker*), 10 specimens, both sexes, taken on *Sterculia foetida*.

*Type locality*.—FORMOSA (*Matsumura*).

Several specimens from Bengal were described by me as a new species, *T. elongata*, very closely similar to the Formosan

species. Further comparison of these, however, indicates their identity with *T. acutipennis*. This indicates a very wide distribution of the species.

**Tenaphalara fascipennis** Crawford.

*Strogylocephala fascipennis* CRAWFORD, Philip. Journ. Sci. § D 12 (1917) 166, pl. 1, fig. 12.

The study of several newly discovered species of Malayan psyllids evidently related to *Tenaphalara* has led me to group together in this genus not only these new species but also the related and more or less intermediate Philippine form for the reception of which a new genus had been erected, *Strogylocephala*. As this was a monotypic genus, this name becomes synonymical with *Tenaphalara*.

LUZON, Laguna Province, Los Baños.

**Tenaphalara malayensis** sp. nov. Plate II, fig. 3.

Length of body, 3 millimeters; forewing, 3.3. General color flavous to fulvous; thoracic dorsum with slightly darker streaks; vertex brown; antennal segments 3 to 10 black or brown; front and middle tibia brown; eyes black.

Head about as broad as thorax. Vertex a little broader than long, quadrate, with posterior ocelli elevated and a prominent, hornlike, flattened epiphysis on each side between antennal base and posterior ocellus. Genæ swollen beneath antennal sockets and slightly protruding roundly in front of vertex, covering frons; clypeus long, narrowly rounded at apex; beak long. Antennæ about four times as long as width of head, closely approximate at base, segments 1 and 2 short and not very thick, but segment 3 distinctly thicker than succeeding segments. Eyes prominent.

Thorax narrow. Legs long and slender; hind tibiæ with a large spur at base and four black spines at apex. Forewings hyaline, clear, venation as in congeners, but pseudovein between radius and radial sector often wanting.

Abdomen long. Male forceps short, slender, subacutely pointed; anal valve shaped somewhat as in *Aphalara*, with a caudally directed lobe which is nearly as long as basal width. Female genital segment about two-thirds as long as abdomen; valves subequal in length but dorsal blunt at apex and ventral very acutely pointed; dorsal valve with a single horizontal row of twenty or more hairs around end; ovipositor stout, exserted.

PENANG (*Baker*), 2 females. SINGAPORE (*Baker*), 1 male and 2 females.

Tenaphalara juliana sp. nov.

Closely related to *T. malayensis*, differing as follows: Antennæ slender throughout, third segment not thicker than succeeding ones; legs slenderer and shorter; forewings without pterostigma and the marginal cells relatively different in size.

BORNEO, Sandakan (*Baker*), 1 example (genitalia broken off).

Tenaphalara striata sp. nov. Plate II, fig. 5.

Length of body, 2.7 to 3.1 millimeters; forewing, 3 to 3.4. General color orange yellow or fulvous, with narrow black markings on vertex and thoracic dorsum; vertex with five black stripes, one on median line and two on each side; abdomen brownish; femora brown apically; antennæ dark at tip of each segment; forewings hyaline, with several small brown flecks in distal third.

Head not quite as broad as thorax, vertex broader than long, rectangular, nearly straight across front margin, more nearly flat than in congeners, with a slight depression on each side of median line; genæ bulging roundly forward in front of vertex and beneath antennal sockets, covering frons, with a pair of very small, approximate, acutely pointed, conical processes far back just in front of clypeus. Frons not visible except at front ocellus. Antennæ about twice as long as width of head, slender. Beak long.

Thorax moderately broad and robust; metascutellum with two small, blunt epiphyses dorsad. Legs stout; hind tibiæ with a large spur at base and four black spines at apex, one longer than the others and bifid. Forewings long and narrow, hyaline, with a whitish tinge, several black flecks on blisterlike elevations on membrane and a few on veins in distal third; marginal cells subequal.

Abdomen moderately long. Male forceps about as long as anal valve, slender, arched, slightly enlarged at tip; anal valve constricted at base and subspherically swollen above the narrow base, outline in lateral view subcircular. Female genital segment long, nearly as long as abdomen; dorsal valve with a large prominent dorsal projection caudad of large anus, rounded broadly at its apex and bearing a single horizontal row of about ten long setæ; apex of dorsal valve acute and, with acute point of ventral valve, closely embracing the stout ovipositor.

SINGAPORE (*Baker*), 1 pair.

This is obviously close to the typical *Tenaphalara* but somewhat different in the shape of head.

Tenaphalara triozipennis sp. nov. Plate II, fig. 6.

Length of body, 2.1 millimeters; forewing, 2.4. General color reddish brown; thoracic dorsum with several lighter streaks; vertex with four black stripes; venter and legs paler; antennæ light brown; black at tip.

Head scarcely deflexed, nearly or quite as broad as thorax; vertex about as long as broad, somewhat quadrate in outline but anterior portion sharply bent downward, median suture impressed and black, and a parallel black sulcus on each side of it; posterior ocelli small, not elevated; front ocellus not visible from above. Genæ not quite covering frons, scarcely swollen beneath antennal bases, cones wanting. Antennæ a little longer than width of head, slender. Eyes large. Rostrum long.

Thorax scarcely arched, narrow; pronotum moderately long. Legs slender; hind tibiæ with a small spur at base and several short black spines at apex. Forewings narrow, acutely pointed, with several marginal brown spots and apical third maculated irregularly with brown, pterostigma wanting; venation triozine, but resembling that of *Tenaphalara* also.

Abdomen slender, long. Female genital segment long, nearly as long as abdomen, constricted midway; dorsal valve more constricted than ventral, with distal half bluntly rounded at apex.

SINGAPORE (*Baker*), 1 female.

This is a very interesting species, for it is unmistakably closely allied to *Tenaphalara*, resembling especially *T. sulcata* in characters of the head, genitalia, and thorax, but differing in one important venational feature in which the species is distinctly triozine. The absence of the cubital petiole has always been used as the basis for segregating the subfamily Triozinæ, but there are several species which seem to weaken this view. *Pauropsylla triozoptera*, several species of *Rhinopsylla*, and now this new species—all point to a possible fallacy in the current classification.

PSYLLINÆ

In the North Temperate Zone the Psyllinæ is the most numerously represented of the subfamilies, the Triozinæ ranking a close second. In the Tropics, however, there are far fewer species of this subfamily, the Pauropsyllinæ and the Carsidarinæ being the largest. Australia has a good many species of *Psylla*, but their habitat is scarcely tropical. Of the ten or more Temperate Zone genera only three (*Psylla*, *Arytaina*, and *Euphalerus*) are known thus far to have representatives in the Palæotropics,

while two others (*Epipsylla* and *Metapsylla* appear to be limited to these Tropics. These five genera are included in the following key, a more nearly complete synopsis of the subfamily being available in my monograph.

Subfamily characteristics are not numerous. The genæ are always more or less produced into either conical or flattish, spatulate processes, vertex not cleft in front, usually more or less flat; antennæ always slender, either short or long. Basal tarsus of hind legs always with two clawlike spines at apex; hind tibiæ with or without basal spur. Forewings oval or rhomboidal, very seldom acutely pointed at apex, always with cubital petiole (media and cubitus with common stem).

The most closely related subfamily appears to be Pauropsyllinæ, and this differs in several characteristics, chiefly the almost humpbacked thorax, the usually absent genal processes, usually visible frons, short metacoxal spurs, and several others of less constancy.

Although not strictly a part of the palæotropical fauna, Froggatt's Australian genera of this subfamily are included in the following key:

*Key to the genera.*

$a^1$. Genal processes conical, acutely or bluntly pointed; pterostigma of forewing closed (occasionally wanting); antennæ at least longer than width of head.

  $b^1$. Genal cones as long as or longer than vertex, slender and acute, directed forward; antennæ very long, usually longer than body, forewing with or without pterostigma............ Epipsylla Kuwayama.

  $b^2$. Genal cones shorter than vertex, usually directed more or less downward.

    $c^1$. Pleural suture of prothorax extending to middle of lateral extremity of pronotum; genal cones broad and bluntly rounded, usually extending more or less parallel with plane of vertex; forewings often maculated........................................................ Arytaina Foerster.

    $c^2$. Pleural suture of prothorax extending obliquely to posterior corner of lateral extremity of pronotum; genal cones usually declivous, more or less acutely pointed; forewings usually clear. Psylla Geoffroy.

$a^2$. Genal processes flat, broad, not conical in outline; antennæ seldom long, usually very short.

  $b^1$. Genal processes large, broad, more or less quadrate, scarcely divergent; antennæ seldom very short, though usually moderately so.

    $c^1$. Genal processes in same plane with vertex; flat; eyes more or less recessive and flattened; forewing often rhomboidal, with closed pterostigma or none.............................. Euphalerus Schwarz.

    $c^2$. Genal processes depressed somewhat from plane of vertex; scarcely flat; eyes usually hemispherical; forewings not rhomboidal, with pterostigma............... Arytaina Frst. also Eucalyptolyma Froggatt.

  $b^2$. Genal processes short and rather broad; antennæ very short.

$c^1$. Pterostigma wanting; veins not sinuous. ..... **Brachypsylla** Froggatt.
$c^2$. Pterostigma of forewing present and closed; veins sinuous; antennæ not longer than width of head.............. **Metapsylla** Kuwayama.
$c^3$. Pterostigma present but open.
$d^1$. Wings membranous; eyes flattened .. **Syncarpiolyma** Froggatt.
$d^2$. Wings coriaceous; eyes reniform...... .......... **Eriopsylla** Froggatt.

## Genus EUPHALERUS Schwarz

Head nearly or quite as broad as thorax, strongly deflexed; vertex flat, often rugulose, with posterior ocelli scarcely elevated and anterior ocellus visible from above; genal cones large, flat, continuing plane of vertex almost without interruption, usually quadrate; eyes large, somewhat recessive; antennæ variable in length.

Thorax strongly arched and broad; propleural suture extending to middle of end of pronotum, mesonotum large; legs robust, hind tibiæ usually with basal spur; forewings large, broad, rounded or somewhat angulate at apex; membrane thick, subhyaline or opaque, maculated or unicolorous; pterostigma present.

Type of the genus, *Euphalerus nidifex* Schwarz.

Four species are recorded from North America. Five are now known from the Eastern Hemisphere.

*Key to the species.*

$a^1$. Head and thorax with a prominent black stripe from tip of genæ to base of forewings and continued along posterior margin of forewing.
$b^1$. Forewing with distinct pterostigma; first marginal cell larger than second; genal cones quadrate, not at all divergent; vertex deeply rugose or vermiculate-punctate. (South India and Bengal.)
**E. vittatus** Crawford ('12: 423).
$b^2$. Forewing with pterostigma small or wanting; first marginal cell a little smaller than second; genal cones slightly divergent; vertex only slightly rugulose. (Philippines.)
**E. nigrivittatus** Crawford ('13:298).
$a^2$. Head and thorax without lateral black stripes; forewings maculated.
$b^1$. Length to tip of folded wings not over 3 millimeters; antennæ not more than twice as long as width of head; genal cones somewhat divergent, not quadrate.
$c^1$. Forewing much more than twice as long as broad, narrow in basal half; thorax not mottled with brown; inhabiting *Citrus*. (Philippines, Formosa, Java, Malay Archipelago, Bengal, southern India, and southern China.)........ ... ..... **E. citri** (Kuwayama).
$c^2$. Forewing scarcely twice as long as broad, broad in basal half, thorax mottled with brown. (Fiji.)............ **E. maculosus** sp. nov.
$b^2$. Length to tip of folded wings over 4 millimeters; antennæ three times as long as width of head; genal cones quadrate, not divergent; forewings slightly rhomboidal. (Malay Archipelago.)
**E. grandis** sp. nov.

**Euphalerus grandis** sp. nov. Plate II, fig. 7.

Length of body, 3.1 millimeters; forewing, 3.2. General color yellowish or greenish brown, mottled on thoracic dorsum, and often on vertex also, with brown; tarsi brown; antennæ black at tip of each segment and apical two segments brown; forewings mottled and banded with brown.

Head not as broad as thorax, strongly deflexed. Vertex quite flat, rugulose, with a very shallow concavity on each side of median line, a small tubercle on each outer angle behind antennal base, a little more than half as long as broad, anterior ocellus on top. Genal cones large, broad, flat, quadrate, two-thirds as long as vertex, on same plane with vertex, nearly contiguous along inner margin, with thick, white pubescence distad. Eyes large, black, somewhat recessive. Antennæ more than three times as long as width of head, very slender.

Thorax very broad, robust, strongly arched. Pronotum long, mesonotum very large. Legs thick; hind tibiæ with a very small spur at base and several black spines at apex. Forewings large, broad, subrhomboidal, veins thick, alternately brown and flavous, membrane thick, flavous, subhyaline, maculated with numerous small brown spots which are aggregated along apical margin into a broad band; pterostigma very large and broad. Hind wings smaller, thin, hyaline, delicate.

Abdomen rather short, thick, humped upward. Male forceps about two-thirds as long as anal valve, relatively thick, bluntly rounded at apex, sides subparallel; anal valve simple, broadest at base and narrowing slightly toward apex. Female genital segment very short, dorsal valve a little longer than ventral, apex subacute and sometimes flexed upward, with long hairs near middle and short bristles at apex.

MOLUCCAS, Toeal (*Muir*), 3 females. TENIMBER ISLANDS, Larat (*Muir*), December, 1907, 3 females and 1 male.

**Euphalerus maculosus** sp. nov. Plate II, fig. 8.

Length of body, 1.9 millimeters; forewing, 2. General color mottled brown and greenish or dirty white; femora brown, tibiæ pale; antennæ brown at apex of each segment; forewings conspicuously mottled and maculated with brown.

Head small, deflexed, about as broad as prothorax, much narrower than mesothorax across base of forewings. Vertex more than half as long as broad, flat, rugulose, anterior ocellus above; genal cones short, less than half as long as vertex, flat, in same

plane with vertex, divergent, subacutely pointed. Antennæ less than twice as long as width of head, slender.

Thorax broad, arched, legs rather short; hind tibiæ without basal spur, and apical spines short. Forewings subcoriaceous, not transparent, somewhat rhomboidal, veins thick, pterostigma incomplete, membrane and veins spotted and mottled. Hind wings clear, delicate.

Abdomen short. Male forceps about two-thirds as long as anal valve, narrow, subacute at apex, sides parallel; anal valve longer, slender, broadest at base, upper third narrowed.

FIJI ISLANDS, Rewa (*Muir*), March, 1906, 3 males.

Euphalerus vittatus Crawford ('12: 423).

One slightly damaged specimen (female) probably of this species is at hand, collected at Madhavgiri, Bombay, India (*H. H. Mann*), May, 1916, on *Cassia fistula*. The lateral vitta of thorax is wanting and the wing is more extensively mottled with brown. Structurally this specimen resembles the species, but superficially there are some differences. Additional material will show whether or not there are two species in India on the same food plant.

Euphalerus nigrivittatus Crawford ('13: 298).

This species described from one female. Subsequently three additional examples, 1 male and 2 females, of the species have been collected by C. F. Baker at Davao, Mindanao. The description of the male genitalia is now added to the original description.

*Male.*—Forceps moderately broad at base, narrowing to middle, then abruptly broadened and deeply emarginate at apex, terminating in two points; anal valve longer than forceps, apical half much narrower than base.

The presence of a distinct basal spur on each hind tibia was not mentioned in the first description and is now added.

*Distribution.*—LUZON, Laguna Province, Los Baños (*Baker*). MINDANAO, Davao (*Baker*).

Euphalerus citri (Kuwayama).

*Diaphorina citri* KUWAYAMA, Trans. Sapporo Nat. Hist. Soc. 2 (1908) 160.

*Euphalerus citri* CRAWFORD, Rec. Indian Mus. 7 (1912) 424, pl. 33, figs. N, O, P; pl. 35, fig. D; Philip. Journ. Sci. § D 8 (1913) 299; 12 (1917) 168.

In Mr. Muir's collection there are six specimens of this pretty citrus psyllid, taken at Macao, near Hongkong, China, November, 1906; also, one from Amboina, Moluccas. No food plant

data accompany these, but elsewhere the species inhabits foliage of *Citrus*. The species appears to be very widely distributed throughout the southern portion of the Eastern Hemisphere.

## Genus ARYTAINA Foerster

*Psyllopa* CRAWFORD.

Head nearly or quite as broad as thorax; vertex usually nearly or quite flat, with anterior ocellus visible from above; genæ produced into conical or subquadrate processes extending forward nearly in same plane with vertex but separated from vertex by impressed line. Eyes large, more or less recessive over propleurites. Antennæ slender, moderately long. Thorax usually strongly arched and broad; propleural suture extending to middle of more or less swollen end of pronotum; hind tibiæ with or without basal spur. Forewings usually broadly rounded, hyaline or colored or rarely subcoriaceous, pterostigma present. Hind wings smaller, hyaline and clear.

*Key to the species.*

$a^1$. Veins of forewing alternately black and yellow or white.

$b^1$. Membrane as well as veins spotted with black or brown; antennæ less than twice as long as width of head; female genital segment not flexed upward at apex.

$c^1$. Antennæ about as long as width of head; forewing with a broad, irregular band of brown at apex, and remainder irregularly spotted. (Malay Archipelago.) ........ **A. pulchra sp. nov.**

$c^2$. Antennæ nearly twice as long as width of head; forewing without apical band, but more uniformly spotted with small maculæ. (Bengal and Ceylon.) ........ A. punctipennis Crawford ('12: 431).

$b^2$. Membrane clear, only veins spotted with black; female genital segment flexed upward at apex. (Singapore.) **A. punctinervis sp. nov.**

$a^2$. Veins of forewings not conspicuously spotted as above. Antennæ at least twice as long as width of head.

$b^1$. Forewings hyaline, clear; marginal cells subequal.

$c^1$. Genal cones subacute; first marginal cell of forewing not quadrate; pterostigma not short and broad. (Bengal.) **A. obscura Crawford ('12: 432).**

$c^2$. Genal cones very broadly rounded at apex; first marginal cell somewhat quadrate; pterostigma short and broad. (Philippines.) **A. iolani sp. nov.**

$b^2$. Forewings colored or maculated, not clear; vertex with a tubercle at each outer angle behind antennal base.

$c^1$. Genal cones broad, broadly rounded or quadrate; forewings not much over twice as long as broad.

$d^1$. Forewings unicolorous, without marginal bands.

$e^1$. Forewings flavous; insect about 3 millimeters long to tip of folded wings. (Singapore.) ........ **A. flava sp. nov.**

$e^2$. Forewings brown; tubercles on vertex large; insect 4 millimeters long to tip of folded wings. (Philippines.)
A. tuberculata Crawford ('17: 169).

$d^2$. Forewings not unicolorous, margins darker, banded.

$e^1$. Forewings with an apical band of solid color or made up of small spots, and costal margin often darker; male forceps spatulate; very broad at apex. (Philippines and Borneo.)
A. variabilis Crawford ('17: 168).

$e^2$. Forewings with an apical and costal band of many small brown spots; male forceps not spatulate, with a prominent convexity on anterior margin (in lateral view). (Malay Archipelago.) ........................ A. meridionalis sp. nov.

$c^2$. Genal cones acutely pointed; short, strongly divergent; forewings about three times as long as broad, mostly brown, with five small clear spots on apical margin. (Singapore.)
A. brevigena sp. nov.

**Arytaina meridionalis** sp. nov. Plate II, fig. 9.

Length of body, 2 millimeters; length of forewing, 2.1. General color pale straw yellow to very light brown; abdomen with brown markings; antennæ brown on apical third; wings brown except in center pale. Body surface finely pubescent.

Head as broad as thorax, deflexed, nearly transversely straight on hind margin. Vertex flat, large, a little more than half as long as broad, with a shallow depression on each side of median line, a small tubercle on each outer angle just behind antennal base, pubescent; genal cones broad and large, broadly rounded at apex, about half as long as vertex, a little broader than long, not contiguous on inner margin, only slightly depressed from plane of vertex. Eyes large; anterior ocellus on top. Antennæ very long and slender, about two and one-half times as long as width of head.

Thorax broad, well arched. Legs short and thick; hind tibiæ with a black spur at base, and five black spines at apex. Forewings brown on anterior and apical margins and more or less spotted and maculated on rest of membrane, subcoriaceous, more hyaline in central portion, veins with double row of fine setæ; pterostigma pubescent.

Male forceps nearly as long as anal valve, bluntly rounded and somewhat toothed at apex, straight or slightly concave on posterior margin (profile) and with a prominent convexity on anterior margin midway between base and apex; anal valve simple, converging a little toward apex. Female genital segment about half as long as abdomen, both valves acute, subequal in length.

TENIMBER ISLANDS, Larat (*Muir*), December, 1907, 1 pair.

This appears to be closely related to the Philippine species, *A. variabilis*. In wing colors and venation some of the variable Philippine specimens closely resemble the southern form, but in male genitalia they are distinct though suggestively similar, also.

Arytaina flava sp. nov. Plate II, fig. 10.

Length of body, 2.2 millimeters; length of forewing, 2.3. General color flavous yellow, with several dull-colored streaks on thoracic dorsum; eyes black; antennal segments black at tip of each. Body surface sparsely pubescent.

Head not quite as broad as thorax; vertex flattish, with a small foveal impression on each side of median line; with a small tubercle on each outer angle behind antennal base, front ocellus above. Genal cones a little broader than long, about half as long as vertex, broad at apex, scarcely divergent. Antennæ about twice as long as width of head or less, very slender.

Thorax broad, well arched. Legs short, thick; hind tibiæ with spur at base and five or six black spines at apex. Forewings flavous, broadly rounded, veins setigerous, venation somewhat similar to that of *A. meridionalis*.

Male genital segment short; forceps about two-thirds as long as anal valve; moderately stout, not tapering much toward apex, bluntly rounded at tip; anal valve inclined caudad in apical third, a little broader at base than apex, narrow apically.

Female genital segment half as long as abdomen or more, both valves acute or subacute, subequal in length.

SINGAPORE (*Baker*), 2 females. BORNEO (*Baker*), 1 male and 1 female. The latter differ slightly from the Singapore specimens in having shorter antennæ, and the second marginal cell of forewing not quadrate. All appear, however, to be representatives of the same species.

Arytaina iolani sp. nov. Plate II, fig. 11.

Length of body, 2 to 2.3 millimeters; forewing, 2 to 2.3. General color flavous to orange red, eyes black; antennæ black at tip of each segment; forewings slightly flavous. Body surface glabrous.

Head nearly as broad as thorax, deflexed. Vertex flat, about half as long as broad, with a very shallow depression on each side of median line, with a small tubercle on each outer angle behind antennal base. Genal cones as broad as long, broadly rounded at apex, somewhat divergent. Antennæ a little less than twice as long as width of head.

Thorax arched, broad. Legs moderately long and slender;

hind tibiæ with spur at base. Forewings hyaline, veins yellow, with three small brown spots on apical and posterior margins; pterostigma short.

Male forceps a little more than half as long as anal valve, shaped irregularly somewhat as in *A. meridionalis;* anal valve plain, narrowing toward apex. Female genital segment as long as abdomen, slender; dorsal valve a little longer than ventral, both acute.

LUZON, Laguna Province, Los Baños (*Baker*), 1 pair.

The male genitalia, shape of head, and venation of forewing point to a close relationship between this species and *A. meridionalis*, of the Malay Archipelago; and it appears, also, that *A. flava*, of Singapore, is related to both.

**Arytaina brevigena** sp. nov. Plate III, fig. 4.

Length of body, 2.2 millimeters; forewing, 2.3. General color chocolate brown with fine reddish spots and markings on thorax and larger reddish areas on vertex; legs variegated chocolate brown and light brown; antennæ black on apical half of each segment, rest flavous; forewings brown, lighter in central portion; with five round clear spots on apical margin.

Head nearly as broad as thorax, not much deflexed. Vertex about half as long as broad, with a foveal depression on each side of median line and a blunt, thick tubercle on each outer angle behind antennal base. Genal cones short and strongly divergent, acutely pointed, extending only a very little beyond antennal socket; antennæ three times as long as width of head, slender.

Thorax not strongly arched, narrower than in many congeners, pubescent with very short, fine hairs. Femora short and thick; hind tibiæ longer, slender, with a small spur at base. Forewings uniformly broadening from base to apex, latter rounded, margins nearly straight, veins setigerous, dark; membrane black or brown except in central portion of wing and five small spots on apical margin.

Female genital segment about two-thirds as long as abdomen; acutely pointed, dorsal valve longer than ventral, with a prominent constriction on dorsal valve beyond end of anal opening, terminal half acuminate and slender.

SINGAPORE (*Baker*), 4 females (2 in poor state of preservation).

**Arytaina pulchra** sp. nov. Plate III, fig. 3.

Length of body, 2.2 millimeters; forewing, 2.3. General color brown; vertex dirty brown, thorax reddish or chestnut brown;

antennæ black at tip of each segment; femora dark, tibiæ light brown; forewings maculated with brown on veins and membrane, and apical portion solid brown, membrane whitish between maculæ.

Head not as broad as thorax, well deflexed; vertex nearly flat, slightly convex at median line in anterior portion, a little more than half as long as broad, slightly rugulose; genal cones nearly in same plane with vertex, quadrate, broad on apical margin, nearly contiguous, a little less than half as long as vertex, slightly pubescent. Antennæ scarcely longer than width of head.

Thorax broad and strongly arched, pronotum moderately long. Legs thick; hind tibiæ without basal spur. Forewings subhyaline, slightly rhomboidal, veins thick and alternately brown and whitish; membrane whitish between brown maculæ which are scattered over membrane and at apex are concentrated into a broad, brown band; pterostigma short and broad.

Female genital segment very short, dorsal valve a little longer than ventral, both acute.

TENIMBER ISLANDS, Larat (*Muir*), 1 female.

Arytaina punctinervis sp. nov. Plate III, fig. 1.

Length of body, 1.5 millimeters; length of forewing, 1.5. General color black variegated with orange red; dorsum of head and thorax mostly orange red with many black markings and figures; abdomen and venter mostly black with red markings; genal cones red above and below, and black laterad; antennæ with alternating black and orange bands; forewings hyaline, veins and margins alternately black and yellow; legs orange, with black dots and bands.

Head not as broad as thorax. Vertex flat or slightly convex with a narrow, black, foveal depression on each side of median suture, a little more than half as long as broad. Genal cones about two-thirds as long as vertex, subacute, somewhat divergent, nearly in same plane with vertex. (Antennæ mutilated.)

Thorax well arched, robust. Legs short, small; hind tibiæ without basal spur. Forewings broadly rounded, hyaline, conspicuously marked somewhat as in *A. punctipennis*, but membrane between veins not maculated as in that species.

Female genital segment about half as long as abdomen, dorsal valve longer than ventral, flexed upward and very acutely pointed at apex; ventral valve acute.

SINGAPORE (*Baker*), 1 female.

This species is apparently closely related to *A. punctipennis*,

a species found in Bengal and Ceylon. The differences between the two species are sharp but do not conceal their close relationship.

**Arytaina punctipennis** Crawford.

*Psyllopa punctipennis* CRAWFORD, Rec. Indian Mus. 7 (1912) 431, pl. 34, figs. K, O; pl. 35, fig. U.
*Arytaina punctipennis* CRAWFORD, Philip. Journ. Sci. § D 12 (1917) 170.

*Distribution.*—BENGAL, Pusa. CEYLON, Peradeniya.
*Food plant.*—Indigo (*Indigofera*).

**Arytaina obscura** Crawford.

*Psyllopa obscura* CRAWFORD, Rec. Indian Mus. 7 (1912) 432, pl. 34, fig. S; pl. 35, fig. M.

*Distribution.*—BENGAL, Pusa.
*Food plant.*—Mango (*Mangifera*).

**Arytaina variabilis** Crawford ('17: 168).

*Distribution.*—MINDANAO, Butuan, Davao. LUZON, Tayabas Province, Malinao: Laguna Province, Mount Banahao.
BORNEO, Sandakan (*Baker*), 1 male.

**Arytaina tuberculata** Crawford ('17: 169).

*Distribution.*—MINDANAO, Davao.

### Genus EPIPSYLLA Kuwayama

Head long, not strongly deflexed, vertex rather flat, genal cones very long, longer than vertex, conical and more or less divergent, porrect; eyes large; antennæ long, slender. Thorax not strongly arched; pronotum long. Forewings hyaline, rounded at apex, pterostigma distinct or nearly wanting.

The general aspect of the body is similar to that of *Psylla*, but the very long genal cones easily distinguish this genus.

Type of the genus, *Epipsylla albolineata* Kuwayama.

*Key to the species.*

$a^1$. Head and thorax with a pair of conspicuous white or yellow, black-margined stripes from tip of genal cones to base of abdomen, where they meet.
  $b^1$. Head with a second pair of white, black-margined stripes, one from each antennal socket to posterior ocellus; pterostigma of forewing narrow; male forceps with a long tooth on inner face; genal cones about as long as vertex. (Philippines and Malay Archipelago.) **E. pulchra** Crawford ('13: 297).
  $b^2$. Head without second pair of white stripes; pterostigma wanting; male forceps without inner tooth; genal cones longer than vertex. (Formosa.) ......... **E. albolineata** Kuwayama ('08: 178).

$a$. Head and thorax without white stripes.

$b$. Pterostigma of forewing wanting; antennæ one and one-half times as long as body (without wings); forceps distinctly shorter than anal valve; much of thoracic dorsum red. (Formosa.)

E. rubrofasciata Kuwayama ('08: 179).

$b$. Pterostigma large; antennæ about as long as body (without wings); forceps longer than anal valve; thoracic dorsum orange yellow. (Philippines and Malay Archipelago.)

E. forcipata Crawford ('17: 167).

Epipsylla pulchra Crawford ('13: 297).

This species has been taken by C. F. Baker at three stations in the Philippine group; namely, Los Baños and Baguio, Luzon; and Davao, Mindanao. Frederick Muir has taken one male on Amboina, in the Moluccas. This specimen has all the characteristics of the Philippine specimens except that the forceps of the male genitalia have a much smaller tooth on the inner face.

Epipsylla forcipata Crawford ('17: 167).

The type locality of this species is Puerto Princesa, Palawan, Philippine Islands. The distribution seems to be wider, however, for a single female has been taken by C. F. Baker on Penang Island.

## Genus PSYLLA Geoffroy

This genus is a large one and is widely distributed. Its taxonomic definition is not wholly clear, as it embraces at present species which probably should properly not be included. Several Australian species, for example, and a few Asiatic species are probably generically distinct but at present are not separated. A full description and a discussion of the genus are given in my monograph of this family.

In the following key an attempt has been made to include all described species of the South Pacific, Australia, southern Asia and its islands, including Formosa, and the Philippine and Malay Archipelagoes. Many of these species are known to me only by their descriptions, so that the key must be more limited in value than it might be otherwise.

### *Key to the species.*

$a^1$. Forewings hyaline, clear, not colored, veins usually brown or black.

$b^1$. Body bright red; antennæ about two and one-half times as long as width of head.

$c^1$. Genal cones longer than vertex; male forceps spatulate, broad at apex; antennæ and legs reddish. (Philippines.)

P. colorada Crawford ('17: 170).

$c^2$. Genal cones shorter than vertex; forceps acutely pointed; antennæ and legs whitish. (Formosa.).... P. coccinea Kuwayama ('08: 171).

$b^2$. Body not bright red.

$c^1$. Genal cones longer than vertex.

$d^1$. Antennæ three-fifths as long as costa; forewings always clear; body yellowish red, with notal streaks. (Formosa.)
P. arisana Kuwayama ('08: 168).

$d^2$. Antennæ one-half as long as costa; forewings sometimes slightly yellowish; body yellowish brown with notal streaks. (Formosa.) .......... P. kiushuensis Kuwayama ('08: 174).

$c^2$. Genal cones not longer than vertex.

$d^1$. Antennæ about twice as long as width of head.

$e^1$. Genal cones subacutely pointed, distinctly conical in shape.

$f^1$. Body brown; forewings with a black spot at tip of claws. (India.) .......... P. simlæ Crawford ('12: 426).

$f^2$. Body orange yellow, with conspicuous black and white markings on thoracic dorsum and vertex; wing clear, without black spot. (Philippines.) .......... P. bakeri sp. nov.

$e^2$. Genal cones broadly rounded; forewings without black spot. (Australia.)

$f^1$. Body pubescent, light brown; genal cones small; male forceps fingerlike; on *Acacia pendula*. (Australia.)
P. acaciæ-pendulæ Froggatt ('01: 247).

$f^2$. Body not pubescent, gray, genal cones large; on *Acacia pendula*. (Australia.).... P. gracilis Froggatt ('03: 327).

$d^2$. Antennæ four or five times as long as width of head; forewing without pterostigma.

$e^1$. Genal cones well separated and divergent, about as long as vertex and of similar color; costa of forewing not hairy. (Philippines.) .......... P. leprosa sp. nov.

$e^2$. Genal cones not divergent, contiguous distad, not as long as vertex, white, costa of forewing hairy. (Fiji Islands.)
P. compta sp. nov.

$a^2$. Forewings not clear, more or less flavous, fumate or colored.

$b^1$. Forewings not opaque, more or less transparent.

$c^1$. Forewings not mottled nor maculated.

$d^1$. Forewings about three times as long as broad.

$e^1$. Antennæ about twice as long as width of head or more; body reddish brown.

$f^1$. Thorax mottled with black; legs long; genal cones not very small; body about 1.6 millimeters long. On *Acacia pycnantha*. (Australia.)
P. acaciæ-pycnanthæ Froggatt ('01: 243).

$f^2$. Thorax not mottled; legs short; genal cones very short, not visible from above; body about 1 millimeter long. On *Acacia decurrens*. (Australia.)
P. candida Froggatt ('01: 252).

$e^2$. Antennæ scarcely longer than width of head; body ocherous; male forceps slender. On *Sterculia*. (Australia.)
P. sterculiæ Froggatt ('01: 255).

$d^2$. Forewings about two and one-half times as long as broad or less, body color dull yellowish or brown.

$e^1$. Insect small, body 0.9 millimeter long; genal cones short, quadrate; male forceps thick, short. On *Acacia dealbata*. (Australia.) ........ P. acaciæ-dealbatæ Froggatt ('03: 326).

$e^2$. Insect larger, body nearly or quite 2 millimeters long.

$f^1$. Genal cones nearly as long as vertex, subacute; body color dull yellow. (Formosa.)
P. toroensis Kuwayama ('08: 172).

$f^2$. Genal cones scarcely half as long as vertex, rounded at apex; body color brown with white markings. (Malay Archipelago.) .................................... P. muiri sp. nov.

$c^2$. Forewings mottled, maculated or banded.

$d^1$. Forewings about twice as long as broad, covered with numerous small dark spots; body color dull yellowish; antennæ rather short.

$e^1$. Genal cones about as long as vertex, truncate at apex; wings yellowish, body not pubescent. (Formosa.)
P. tripunctata Kuwayama ('08: 174).

$e^2$. Genal cones very short, broad, rounded; wings gray, semiopaque; dorsum of body gray, pubescent. On *Acacia baileyana*. (Australia.)
P. acaciæ-baileyanæ Froggatt ('01: 257).

$d^2$. Forewings not covered with numerous small spots, but irregularly clouded or banded.

$e^1$. Thorax and head yellowish; wings about three times as long as broad, semiopaque, mottled with brown; antennæ long, genal cones rather large, broad. On *Acacia* sp. (Australia.)
P. frenchi Froggatt ('01: 245).

$e^2$. Thorax and head brown or black.

$f^1$. Forewings subhyaline, more or less fumate or dark in apical portion; body moderately large.

$g^1$. Antennæ as long as forewings or longer; forewings irregularly fumate throughout, darker apically; insect over 4 millimeters long.

$h^1$. Genal cones as long as vertex; female genital segment as long as abdomen. (Philippines.)
P. crenata Crawford ('17: 171).

$h^2$. Genal cones scarcely two-thirds as long as vertex; female genital segment one-third as long as abdomen. (Borneo.) ........................................................ P. fumosa sp. nov.

$g^2$. Antennæ about half as long as forewings; wings glassy, with a brown band from tip of clavus to tip of radius; insect about 3 millimeters long. (Formosa.)
P. spadica Kuwayama ('08: 165).

$f^2$. Forewings semiopaque, broadly and irregularly clouded with brown.

$g^1$. Thorax brown with yellowish patches and markings. On *Acacia implexa*. (Victoria.)
P. lidgetti Maskell. Froggatt ('01: 245).

$g^2$. Thorax black or dark brown; genal cones very small; antennæ short; wings about twice as long as broad, with a large whitish area near middle and rest brown or mottled. On *Acacia juniperina*. (Australia.)
P. acaciæ-juniperinæ Froggatt ('03: 328).

$b^2$. Forewings opaque, mottled with brown; genal cones acutely conical; wings about twice as long as broad.

$c^1$. Thorax ocherous, mottled with brown; forceps long and slender.

$d^1$. Genal cones very long, acutely pointed; antennæ very long; legs long; wings twice as long as broad. On *Acacia decurrentis*. (Australia.)........ P. acaciæ-decurrentis Froggatt ('01: 248).

$d^2$. Genal cones short, broad at base, acutely pointed; antennæ moderately short; legs short; wings less than twice as long as broad. On *Capparis mitchelli*. (Australia.)
P. capparis Froggatt ('01: 250).

$c^2$. Thorax dark brown, mottled with dull yellow; forceps short; genal cones large, moderately long, pointed; antennæ very short; legs short. On *Apophyllum anomalum*. (Australia.)
P. schizoneuroides Froggatt ('01: 253).

**Psylla fumosa** sp. nov.

Length of body, 2.3 millimeters; forewing, 3. General color brown, with small lighter areas about base of wings and on pronotum; antennæ brown except basal one-fourth yellowish; forewings smoky, a little more densely browned irregularly in apical portion. Body surface pubescent with short, fine hairs.

Structurally similar to *P. crenata* Crawford ('17: 171), to which species this is apparently closely related, differing as follows: Genal cones about two-thirds as long as vertex, bluntly rounded at apex, somewhat divergent; antennæ a little longer than forewings but not quite as long as body and wings combined; thorax more slender; wing venation similar, except cubital petiole (M+Cu) only half as long as stem of cubitus (Cu), while in *P. crenata* it is nearly three-fourths as long; forewing narrower relatively.

Male forceps stout, as long as anal valve, somewhat falcate, broadest midway and arched forward, subacutely pointed; anal valve moderately long, tapering from base to apex, apical third slender and inclined backward. Female genital segment short, about one-third as long as abdomen.

BORNEO, Sandakan (*Baker*), 1 male and 1 female.

This is a close relative of *Psylla crenata* but is surely distinct. It approaches to a confusing degree certain species of *Arytaina*.

**Psylla leprosa** sp. nov. Plate III, fig. 8.

Length of body, 2 millimeters; forewing, 2.9; antennæ, 4.2 General color lemon yellow with leprous-white areas; vertex in center of pronotum, posterior edge of dorsulum, paraptera, and metascutum white; legs pale; wings clear or slightly yellow, antennal segments 1 and 2 pale, 3 black at extreme tip, 4 black on distal third, 5 black on distal half, 6 black on distal two-thirds, 7 pale at base, 8 to 10 black.

Head broad and short, about as broad as thorax, deflexed; vertex scarcely half as long as broad between eyes, roundly convex on each side of median line in front, posterior ocelli well elevated; genal cones as long as vertex, subacute, divergent, scarcely contiguous even at base, sparsely hirsute; eyes large; antennæ very long and slender, longer than body to tip of folded wings, more than four times as long as width of head.

Thorax broad, arched, dorsal surface sparsely hairy. Legs rather long and slender; hind tibiæ without spur at base, and apical spines short. Forewings clear or slightly flavous, veins yellow, narrow; pterostigma wanting or very narrow.

Abdomen short. Female genital segment very short, about one-third as long as abdomen, dorsal valve a little longer than ventral, both subacute.

BASILAN (*Baker*), 1 female.

Psylla bakeri sp. nov. Plate III, fig. 9.

Length of body, 1.9 millimeters; forewing, 2.3. General color orange yellow or paler, with conspicuous white and black markings as follows: Pronotum black cephalad and white caudad; dorsulum black on anterior margin, white on posterior margin and center orange colored; mesoscutum black on part of anterior margin; mesoscutellum and metascutum white; vertex with a small black or brown discal area on each side of median suture, and a white area caudad of these and extending to median suture; eyes dark; antennæ orange with apex of each segment brown; wings clear.

Head strongly deflexed, about as broad as thorax, short; vertex not half as long as broad between eyes; roundly convex on each side of median suture in front; with a small, shallow, foveal depression on each side, elevated at posterior ocelli. Genal cones as long as vertex, well separated, and inner margins nearly parallel to near base, subacute. Antennæ a little more than twice as long as width of head, slender.

Thorax broad, arched, not pubescent. Legs rather short, but hind legs long; hind tibiæ without basal spur and distal spines short. Forewings clear or very slightly fumate, veins yellowish, pterostigma large.

Abdomen short. Female genital segment about as long as abdomen, thick at base and narrowing abruptly to acute tip, dorsal valve longer than ventral, both acutely pointed.

LUZON, Laguna Province, Los Baños (*Baker*), 1 female; Benguet Subprovince, Baguio (*Baker*), 1 female.

Psylla compta sp. nov. Plate III, fig. 11.

Length of body, 1.9 millimeters; forewing, 2.3; antennæ, 3.5. General color orange; genal cones entirely white, pronotum posteriorly margined broadly with white, dorsulum on posterior margin narrowly margined with white and two white areas on mesoscutellum; venter of thorax and dorsum of abdomen dark brown; abdomen ventrad pale whitish; legs flavous, except front tarsi brown; antennæ brown except three basal segments orange; forewings clear.

Head strongly deflexed, nearly or quite as broad as thorax; vertex half as long as broad between eyes, elevated at posterior ocelli, with a very small foveal depression on each side of median suture, sparsely hairy, median suture scarcely impressed and narrowly black. Genal cones slender, conical, not quite as long as vertex, acutely pointed in apical half or third, closely appressed to each other, very briefly pubescent. Antennæ very long, five times as long as width of head, segments 3 and 4 slightly thicker than in most species.

Thorax slightly pubescent; legs long, slender, hind tibiæ with basal spur, distal spines numerous. Forewings clear, veins yellow or brownish, costal vein conspicuously hairy; pterostigma narrow or wanting.

Male genital segment moderately small, forceps small, about half as long as anal valve, slender, acutely pointed, simple; anal valve rather long, broadest at base and converging slightly toward subacute apex.

FIJI ISLANDS (*Muir*), 1905, 1 male and 1 imperfect example.

The most characteristic feature of this pretty species is the form of the genal cones which is suggestive of the genus *Neotriozella*.

Psylla muiri sp. nov. Plate III, fig. 5.

Length of body, 2 millimeters; forewing, 2.1. General color chocolate brown with irregular and narrow white markings and stripes on thorax, vertex, and abdomen; legs light brown or femora darker; antennæ pale with apex of each segment darker; forewings fumate or brown, with a dark spot at tip of clavus and three others on posterior margin.

Head deflexed, not quite as broad as thorax, vertex roughly triangular in outline, half as long as broad, with a small protuberance behind eyes on outer margin, a small foveal depression on each side of median suture and the two connected by a shallow transverse fossa. Genal cones scarcely half as long as vertex, narrowly rounded at apex, declivous from vertex, divergent;

antennæ a little more than twice as long as width of head, slender. Eyes larger, somewhat recessive.

Thorax arched, broad, robust. Legs rather short, stout; hind tibiæ with a small spur at base. Forewings short, browned but hyaline, veins with short setæ; pterostigma short and broad.

Abdomen thick. Male forceps not quite as long as anal valve, broadly spatulate in apical half, broad at apex and part of apical margin finely toothed; anal valve simple, broadest at base, narrowing to subacute apex. Female genital segment nearly as long as abdomen, dorsal valve longer than ventral and both acutely pointed.

TENIMBER ISLANDS, Larat, December, 1907 (*Muir*), 10 females. MOLUCCAS, Amboina (*Muir*), 2 males and 1 female.

This species approaches *Arytaina* in some respects, as in the character of genal cones and shape of forewing.

### TRIOZINÆ

The most easily visible, though not the most constant, character of this subfamily is the point of furcation of the basal vein of the forewing—the cubitus, media, and radius leaving the basal vein at quite or nearly the same point. *Ceropsylla* and *Hemitrioza*, both American genera, are exceptions to this. On the other hand, several species belonging to other subfamilies, possess this characteristic, as follows: *Rhinopsylla*, and *Tenaphalara triozipennis*, of the subfamily Carsidarinæ; and *Pauropsylla triozoptera* and *Leptynoptera*, of the subfamily Pauropsyllinæ. However, the exceptions are comparatively few, and this character remains the best for subfamily distinction.

The body is typically slender, eyes hemispheric, frons covered by the genæ (except in *Cerotrioza bivittata*); basal tarsus of hind legs always lacks the clawlike spines which are present in most of the other subfamilies. A full description of the subfamily Triozinæ is given in my monograph, page 64.

*Key to the genera.*

$a^1$. Hind tibiæ without basal spur and without subapical spiniform tooth; no anterior processes of metacoxæ.
- $b^1$. Forewings with three marginal spots, made up of numerous minute punctations, on hind margin.
  - $c^1$. Genal cones present, but not always conical.
    - $d^1$. Genal cones more or less divergent, not closely appressed to each other.
      - $e^1$. Notum scarcely arched; pronotum relatively long; genal cones directed forward ........................................ Leuronota Crawford.
      - $e^2$. Notum well arched; pronotum short; genal cones more or less declivous.

*f*¹. Usually not gall makers, though sometimes leaf curlers. A large varied assemblage of species............... Trioza Foerster.

*f*². Gall makers. A small and poorly defined assemblage of mostly Southern Hemisphere species............... Cecidotrioza Kieffer.

*d*². Genal cones not at all divergent, long and closely appressed to each other............................................ Neotriozella Crawford.

*c*². Genal cones wanting; genæ sometimes swollen beneath antennal sockets; notum usually not much arched...... Kuwayama Crawford.

*b*². Forewings without marginal spots on hind margin; veins usually setigerous.......................................................... Hevaheva Kirkaldy.

*a*². Hind tibiæ with a basal spur (sometimes small).

*b*¹. Antennæ slender, not densely hairy.

*c*¹. Forewings not opaque nor maculated, but transparent, with radius usually short; vertex not produced cephalad into horns; metacoxæ with a pair of anteriorly directed processes; hind tibiæ usually with a conspicuous spiniform tooth near apex; genal cones present or wanting, seldom conical ... Megatrioza Crawford.

*c*². Forewings semiopaque or opaque, maculated, with radius extending nearly to tip; vertex produced cephalad into a pair of horns. Cerotrioza g. nov.

*b*². Antennæ thick and very densely hairy; genal cones present; vertex very broad; forewings transparent, radius long. Stenopsylla Kuwayama.

*Trichochermes* Kirkaldy (Kuwayama '10: 54), as represented by two Japanese species, is not recognized in this work as distinct from *Trioza*. It was separated chiefly on the pubescent or hirsute dorsum, but this makes a very unnatural and wholly unsatisfactory division. At least one species of *Trioza*, named by Kuwayama himself, has the pubescent dorsum characteristic of the other group but was placed by him in *Trioza* rather than in *Trichochermes*. *Trichochermes bicolor* Kuwayama appears to be very close to my *Trioza dirisa*. Both of Kuwayama's species of *Trichochermes* are included in the synoptic key to the species of *Trioza*.

*Epitrioza* Kuwayama ('10: 55), as originally characterized, appears to be not a well-defined genus. Its chief distinguishing character was said to be the position of the forewing apex in relation to the apical veins, but this characteristic is so variable in the genus *Trioza* that confusion and quite unnatural segregation of species would surely result if this criterion were adhered to closely. Kuwayama's characterization of both the genus and its one species is rather incomplete, but certain features suggest a rather close relationship of this to my *Megatrioza*. However, until an opportunity is had to examine material of this Japanese species, I do not wish to make any disposition of it nor to merge *Megatrioza* into it.

### Genus TRIOZA Foerster

*Trioza* is a very large genus of which many of the species are difficult to distinguish. It appears to be a group in which very active evolution of new species is in progress, especially in the North Temperate Zone. In the Tropics and the South Temperate Zone it is much less numerously represented, most of the triozine species there being in other genera, chiefly *Megatrioza* with its armed hind tibiæ. With *Cecidotrioza* Kieffer I am unfamiliar. Whether or not it is truly distinct from *Trioza* or *Megatrioza* is not yet clear.

*Key to the species.*

a¹. Hind wings normally developed, at least half as long as forewings.
  b¹. Forewings more or less colored, not wholly clear.
    c¹. Dorsum and vertex hairy; forewings thickened and darkened on basal third, remainder glassy.
      d¹. Forewings nearly three times as long as broad; media and cubitus each forking beyond its midpoint. (Japan.)
        T. (Trichochermes) bicolor Kuwayama ('10: 51).
      d². Forewings two and one-half times as long as broad; media and cubitus each forking at or near its midpoint, making the marginal cells relatively longer. (Philippines.)
        T. divisa Crawford ('17: 172).
    c². Dorsum and vertex not hairy.
      d¹. Forewings somewhat coriaceous, dull opaline in color, about two and one-half times as long as broad. (Tasmania.)
        T. tasmaniensis Froggatt ('03: 329).
      d². Forewings semitransparent, somewhat browned, about four times as long as broad. (Tasmania.)
        T. dobsoni Froggatt ('03: 331).
  b². Forewings not colored, glass clear or sometimes very slightly yellowed or smoky.
    c¹. Forewings broadly rounded at apex, not angular nor acutely pointed, less than three times as long as broad.
      d¹. Genal cones distinctly shorter than vertex.
        e¹. Forewings nearly three times as long as broad; antennæ long; forming galls on *Eucalyptus*.
          f¹. Legs short, stout; genal cones with long hairs. (Australia.)
            T. orbiculata Froggatt ('01: 274).
          f². Legs long and slender; genal cones less hairy. (Australia.)
            T. eucalypti Froggatt ('01: 277).
        e². Forewings not more than two and one-half times as long as broad; antennæ rather short.
          f¹. Body light green; genal cones very short; curling foliage of *Olearus*. (Tasmania.)...... T. clearis Froggatt ('03: 332).
          f². Brown to almost black; genal cones one-half to two-thirds as long as vertex; forming galls on *Metrosideros*. (Hawaii.)
            T. ohiacola Crawford ('18: 442).
      d². Genal cones as long as vertex or sometimes longer.

$e^1$. Antennæ two to three times as long as width of head; dorsum scarcely hirsute; insect small to medium in size.

$f^1$. Genal cones large, broadly rounded at apex, scarcely conical, with long pubescence; forming galls on *Eucalyptus*. (Australia and Tasmania.) T. carnosa Froggatt ('01: 275).

$f^2$. Genal cones more or less acutely pointed, distinctly conical.

$g^1$. Cubitus forked at or very near its midpoint; inhabiting galls on *Metrosideros*.

$h^1$. Costa of forewing with setæ; male forceps notched behind near apex; color usually orange. (Hawaii.)
T. iolani Kirkaldy. Crawford ('18: 441).

$h^2$. Costa of forewing without easily visible setæ; male forceps not notched near apex.

$j^1$. Genal cones longer than vertex; antennæ two and one-half to three times as long as width of head; thoracic dorsum usually striped with brown; male forceps abruptly narrowed near apex. (Hawaii.)
T. lanaiensis Crawford ('18: 443).

$j^2$. Genal cones about as long as vertex.

$k^1$. Color of body black, dorsum reticulately marked; insect about 3.5 to 4 millimeters long. (Hawaii.)
T. pullata Crawford ('18: 444).

$k^2$. Color orange or flavous, dorsum not so reticulated; insect 4 to 5 millimeters long. (Hawaii.)
T. hawaiiensis Crawford ('18: 444).

$g^2$. Cubitus forked distinctly distad of its midpoint.

$h^1$. Body color dark brown; wing veins margined with brown; on *Casuarina*. (Australia.)
T. casuarinæ Froggatt ('01: 284).

$h^2$. Color yellow to orange; wing veins not dark margined.

$j^1$. Antennæ three times as long as width of head, black at tip. (India.) .... T. hyalina Crawford ('12: 428).

$j^2$. Antennæ twice as long as width of head, distal half black. (India and Europe.)
T. urticæ Linn. Crawford ('12: 434).

$e^2$. Antennæ four times as long as width of head; dorsum sparsely hirsute and wing veins setose; insect large.

$f^1$. Genal cones about as long as vertex; wing veins uniform in color from base to apex of wing. (India.)
T. gigantea Crawford ('12: 428).

$f^2$. Genal cones nearly twice as long as vertex; wing veins black in distal half, remainder orange red. (Singapore.)
T. tenuicona sp. nov.

$c^2$. Forewings more or less acutely angled or pointed at apex, not broadly rounded.

$d^1$. Forewings three times as long as broad or longer.

$e^1$. Gall makers.

$f^1$. General color yellowish; forewings very long and acutely pointed; forming galls on *Eucalyptus*. (South Australia.)
T. multitudina (Tepper). Froggatt ('01: 280).

$f^2$. Color reddish brown; forewings very long but very acutely pointed; forming galls on *Tristania*. (Queensland.)
**T. tristaneæ** Froggatt ('03: 334).

$e^2$. Not gall makers; general color greenish, yellowish or light brown.

$f^1$. Radius of forewing very short, straight; antennæ short; insect small, about 1 to 2 millimeters long. (Australia.)
**T. banksiæ** Froggatt ('01: 281).

$f^2$. Radius very long, extending nearly to apex of wing, more or less sinuate; antennæ not very short; insect larger, 3 to 4 millimeters long.

$g^1$. Head black, abdomen brown above and pale beneath. (Japan.) .................... **T. nigriceps** Kuwayama ('10: 60).

$g^2$. Head yellowish green, abdomen green. (Japan and Philippines.) ........................ **T. magna** Kuwayama ('10: 59).

$d^2$. Forewings less than three times as long as broad.

$e^1$. Thoracic dorsum not conspicuously pubescent nor hirsute.

$f^1$. Thorax chiefly black or dark brown; antennæ mostly brown to black, sometimes basal segments pale.

$g^1$. Genal cones black.

$h^1$. Antennæ wholly black or dark brown.

$i^1$. Antennæ about three times as long as width of head; radial stem forking distad of its midpoint. (Japan.)
**T. nigra** Kuwayama ('10: 57).

$i^2$. Antennæ two times as long as width of head; radial stem forking at its midpoint. (India.)
**T. analis** Crawford ('12: 429).

$h^2$. Antennæ with third segment whitish. (Japan, Europe.)
**T. galii** Foerster. Kuwayama ('10: 57).

$g^2$. Genal cones yellow to orange; antennæ twice as long as width of head, black or basal third brown. (Formosa.)
**T. formosana** Kuwayama ('10: 58).

$f^2$. Thorax yellow, greenish or orange to reddish, rarely darker.

$g^1$. Forewings with first marginal cell larger than second; thoracic dorsum yellowish with brown streaks; genal cones short, half as long as vertex. (Formosa.)
**T. brevifrons** Kuwayama ('10: 61).

$g^2$. Marginal cells nearly equal in size.

$h^1$. Radius short, straight.

$i^1$. Genal cones as long as vertex, acute at apex; insect about 4 millimeters long or more.

$j^1$. Antennæ about two and one-half times as long as width of head, black; abdomen green ventrad. (Japan and Europe.)
**T. remota** Frst. Kuwayama ('10: 60).

$j^2$. Antennæ less than twice as long as width of head, light brown; abdomen brown. (Bengal.)
**T. jambolanæ** Crawford ('17: 173).

$i^2$. Genal cones much shorter than vertex, rounded at apex; insect less than 4 millimeters long.

$j^1$. Antennæ more than twice as long as width of head; insect small, about 2.5 millimeters long, forming galls on *Eucalyptus*. (Australia.)
T. circularis Froggatt ('01: 279).

$j^2$. Antennæ very short, not much longer than width of head; insect larger, 3.5 millimeters long, not gall makers. (Bengal, Singapore.)
T. fletcheri Crawford ('12: 434).

$h$. Radius not very short, reaching nearly to tip of wing, often curved or sinuate.

$i^1$. Abdomen and genal cones black, latter as long as vertex. (Japan.)
T. striola Flor. Kuwayama ('10: 62).

$i$. Abdomen and genal cones light brown or yellow; cones shorter than vertex.

$j^1$. Radius of forewing nearly straight or bent inward near middle; antennæ usually pale yellow, but sometimes brown.

$k^1$. Antennæ rather short, not over twice as long as width of head.

$l^1$. Body orange yellow to red, sometimes dark red; insect about 4 millimeters long. (Japan.)
T. salicivora Reut. Kuwayama ('10: 59).

$l^2$. Body green or yellowish, about 3 millimeters to tip of folded wings. (Japan.)
T. viridula Zett. Kuwayama ('10: 61).

$k^2$. Antennæ three times as long as width of head; body bright yellow, abdomen green. (Japan.)
T. silacea M. D. Kuwayama ('10: 58).

$j^2$. Radius of forewing sinuate; antennæ black, thorax yellowish. (Japan.)
T. curvatinervis Foerster. Kuwayama ('10: 62).

$e^2$. Thoracic dorsum more or less conspicuously pubescent or sparsely hirsute; radius short.

$f^1$. Genal cones nearly or quite as long as vertex; forewings very acutely pointed; pubescence moderately dense.

$g^1$. Fore tibiæ with two stout spines at apex; body color yellow to reddish brown; apex of forewing at end of media. (Australia.) .... .. T. eugeniæ Froggatt ('01: 282).

$g^2$. Fore tibiæ without apical spines; body color dark brown; apex of forewing within second marginal cell. (Formosa.)
T. (Trichochermes) hyalina Kuwayama ('10: 55).

$f^2$. Genal cones scarcely half as long as vertex; forewings less acutely pointed, veins setigerous; pubescence very sparse. (Philippines.) . . .. ... T. luzonensis Crawford ('17: 173).

$a^2$. Hind wings greatly aborted, reduced to very small stubs; forewings long and acutely pointed, marginal cells far separated. (Singapore.)
T. diptera sp. nov.

The foregoing key has been arranged in part on descriptions of species which in some instances are too meager and indefinite for

this purpose. It is quite possible, therefore, that some errors may exist in the synopsis; notwithstanding this, the key will serve as an assistance in future work because of the scattered condition of the literature on this subfamily.

Trioza magna Kuwayama ('10: 59).

Length of body, 2.2 to 2.6 millimeters; forewing, 4 to 4.5. General color green or yellowish green; forewings whitish or glass clear; antennæ brown or black; dorsum and vertex briefly and sparsely hairy.

Head nearly as broad as thorax, not strongly deflexed, vertex large, broadly concave, median line deeply impressed in anterior half; genal cones as long as vertex, slender and acute, strongly divergent; antennæ about two and one-half times as long as width of head, moderately thick.

Thorax long and narrow; legs slender, rather long. Forewings long and narrow, nearly four times as long as broad, acute at apex, veins with whitish setæ, membrane whitish in color; first marginal cell larger than second, radius very long.

Male (according to Kuwayama) with anal valve about as long as genital segment, much broadened midway in lateral aspect; forceps simple, about as long as anal valve. Female genital segment nearly as long as rest of abdomen, anus large, valves subequal in length, dorsal acutely pointed.

*Type locality.*—Japan, Hekone, Honshu (*Matsumura*). Philippines—LUZON, Baguio, Benguet (*Baker*), 1 female.

Trioza fletcheri Crawford ('12: 434).

One male specimen taken at Singapore (*Baker*) appears to belong to this species, previous representatives of which were taken in India.

Trioza tenuicona sp. nov. Plate III, fig. 2.

Length of body, 2.2 millimeters; forewing, 4. General color pale brown to dark brown or nearly black; vertex in dark forms light brown; eyes black; antennæ mostly black, basal third sometimes reddish brown; legs light brown or sometimes paler; forewings clear, veins in distal half conspicuously black, yellowish in basal half.

Head broad, nearly as broad as thorax; vertex less than half as long as broad, median suture sulcate cephalad, bulging on each side; genal cones nearly twice as long as vertex, directed vertically downward, slender and acutely pointed, not widely divergent, sparsely hirsute. Antennæ about four times as long as width of head, rather thick.

Thorax arched, broad, with scattering hairs. Legs long and stout; tibiæ very long, hind tibiæ without basal spur, four small spines at apex. Forewings large, broadly rounded at apex, veins thick and heavy, not unicolorous. Hind wings about half as long as forewings or more, narrow.

Abdomen thick. Male forceps half as long as anal valve, rectangular in outline (lateral), truncate at apex, with three teeth on apical margin; anal valve long, broadest at base, tapering to narrow apex. Female genital segment about half as long as rest of abdomen, dorsal valve a little longer than ventral, both subacute.

SINGAPORE (*Baker*), 1 male and 2 females.

**Trioza divisa** Crawford ('17: 172).

The description of the female genitalia, having been omitted in the first account of this species, is given here. Abdomen very short; genital segment short, but nearly as long as abdomen, dorsal valve a little longer than ventral, both subacute and tawny in color.

LUZON, Benguet Subprovince, Baguio (*Baker*), 1 female. The first specimens, 2 males, were from the same locality.

This species is very close to the Japanese *Trichochermes bicolor* Kuwayama, differing in only a few respects as indicated in the foregoing key.

**Trioza diptera** sp. nov. Plate III, figs. 6 and 7.

Length of body, 1.9 millimeters; forewing, 3.1. Thorax orange red, abdomen reddish brown on notum and mostly white on venter; vertex pale brown, with three darker stripes, posterior ocelli red; genæ white; antennæ white, with three broad black rings; legs white or pale; wings clear. Body surface more or less white-pulverulent.

Head nearly as broad as thorax, declivous; vertex nearly as long as broad, median suture sulcate, and a long, slightly crescentic sulcus on each side; genal cones broad at base, acutely pointed, strongly divergent, directed forward, pubescent with white hairs. Antennæ about one and one-half times as long as width of head, slender, conspicuously black and white.

Thorax narrow, not much arched. Legs rather short; hind tibiæ without basal spur, with four black spines at apex, three together and one alone. Forewings long, acutely pointed, transparent, marginal cells far separated. Hind wings reduced to mere stubs, almost wanting.

Abdomen long and slender. Male genital segment unusually

long and slender, nearly as long as abdomen, reaching far caudad of forceps, slender and acuminate; forceps a little longer than anal valve, situated near base of genital segment, somewhat triangular in lateral outline, broadest near base, shortly petiolate, converging to blunt point at apex, scarcely arched toward each other; anal valve small, not as long as forceps, with a fingerlike projection caudad below midpoint. Female genital segment about as long as abdomen, slender, acuminate; ventral valve about half as long as dorsal, latter long and slightly constricted midway.

SINGAPORE (*Baker*), 2 males and 2 females.

This is a very striking species, remarkable for its genitalia and differing from most *Triozæ* in wing characters. It should be perhaps referred to a distinct genus. In the next genus, *Megatrioza*, there is a marked tendency toward abortion of the hind wings.

Genus MEGATRIOZA Crawford

Head more or less declivous, usually not as broad as thorax; vertex broader than long; genal cones usually rather short but in a few species long, usually thick and bluntly rounded; frons concealed. Thorax broad or narrow, strongly arched or sometimes nearly flat, usually sparsely clothed with long hairs; legs long, apparently strongly saltatory; metacoxæ with large posterior spurs and also a pair of spiniform processes extending cephalad between bases of hind legs; hind tibiæ with a small or large spur at base, a more or less conspicuous, thick spine or tooth near apex and three smaller spines at extreme apex. Forewings hyaline, sometimes colored, usually acutely pointed, long and narrow, venation triozine with radius and clavus short. Hind wings usually much reduced, seldom more than half as long as forewings and sometimes very greatly reduced. Abdomen short or long; male anal valve broad, with lateral wings produced caudad.

Type of the genus, *Megatrioza armata* Crawford ('15: 264).

This genus was first erected for a single large and striking species of the Philippines. The subsequent study, however, of additional South Pacific psyllids makes it appear that this genus has very many representatives throughout tropical Asia and the South Pacific Islands, and no doubt in other tropical areas as well.

The most striking characteristics of this generic group are the armed hind tibiæ, unusual in Triozinæ; the secondary metacoxal

spurs directed forward, not found in other genera of the family so far as known to me; and the peculiarly long and slender forewings. So many of the species are known to be gall makers or leaf curlers that it probably is a safe surmise that most or perhaps all of the species have similar habits.

One species of southwestern United States, *Trioza diospyri* Ashm., is beyond doubt a representative of this genus and should be referred to it. It has stood heretofore as a species strikingly different from other American *Triozæ*, but nevertheless remaining in that genus. It is quite possible that certain other species of *Trioza* in other parts of the world must be referred to this genus, also.

*Key to the species.*

$a^1$. Forewing with media forking well beyond its midpoint; first marginal cell usually a little larger than second.

$b^1$. Genal cones rather slender, fully as long as vertex; head scarcely declivous; thorax narrow; hind wings about two-thirds as long as forewings.

$c^1$. Forewings glass clear; antennæ about two and one-half times as long as width of head. (Philippines and Borneo.)
**M. armata** Crawford ('15: 264).

$c^2$. Forewings ocherous, transparent; antennæ twice as long as width of head. (Malay Peninsula.)............ **M. armata ochreata** var. nov.

$b^2$. Genal cones broad and shorter than vertex or wanting; head usually strongly declivous, thorax broad; hind wings about half as long as forewings or sometimes more.

$c^1$. Genal cones nearly as long as vertex, broad at base, subacute; head considerably narrower than thorax; female genital segment acutely pointed. (Philippines.)...................... **M. robusta** sp. nov.

$c^2$. Genal cones about half as long as vertex, bluntly rounded; head nearly as broad as thorax; female genital segment short.

$d^1$. Length of insect to tip of folded wings about 5 millimeters or less; marginal cells of forewing subequal.

$e^1$. Dorsum dark brown to black, usually with reddish or orange longitudinal markings; vertex broadly concave between postocelli; antennæ less than twice as long as width of head; insect about 5 millimeters long. (Philippines, Borneo, and Bengal.)............ **M. eugenioides** Crawford ('17: 171).

$e^2$. Dorsum uniformly yellowish to light brown; vertex scarcely concave between postocelli; insect about 4 millimeters long. (Fiji; Philippines?) ........ **M. vannæ** (Kirkaldy) ('07: 104).

$d^2$. Length of insect about 6 to 7 millimeters; first marginal cell of forewing larger than second.

$e^1$. Cubitus forked at or near its midpoint; antennæ not quite twice as long as width of head; female genital segment large; general color brown to light brown. (Hawaii.)
**M. palmicola** Crawford ('18: 152).

c. Cubitus forked well distad of its midpoint; antennæ more than twice as long as width of head; female genital segment smaller; general color dark brown to black, with reddish or yellowish stripes and markings. (Malay Peninsula.)
**M. gigantea** sp. nov.

c. Genal cones wanting, genæ slightly or considerably swollen beneath antennal bases; vertex and dorsum very hairy; first marginal cell of forewing very large. (India.)
**M. hirsuta** Crawford ('12: 427).

$a^2$. Medial vein forking at or near its midpoint, upper fork ($M_{1+2}$) joining costa at apex of forewing; marginal cells subequal; genal cones shorter than vertex.

$b^1$. Thoracic dorsum black, without lighter markings.

$c^1$. Body slender, nearly all glossy black; hind wings very much reduced; forewings very narrow, radius not margined with black.

$d^1$. Hind wings reaching to tip of abdomen; male anal valve very large and expansive, reaching caudad of forceps. (Philippines.)
**M. magnicauda** sp. nov.

$d^2$. Hind wings reaching about half way to tip of abdomen; male anal valve smaller. (Philippines.)
**M. asiatica** Crawford ('15: 266).

$c^2$. Body robust; thorax dull black; hind wings about half as long as forewings, reaching beyond tip of abdomen; forewings broader, basal vein and radius conspicuously bordered with black. (Philippines.) .......... **M. melanoneura** sp. nov.

$b^2$. Thoracic dorsum brown or lighter, usually more or less striped or banded with orange.

$c^1$. Male forceps acuminate, uniformly tapering to acutely pointed tip; female ovipositor exserted, styliform; antennæ twice as long as width of head. (Philippines and Malay Peninsula.)
**M. stylata** sp. nov.

$c^2$. Male forceps not as above, with a long fingerlike process distad; ovipositor not as above; antennæ less than twice as long as width of head. (Philippines, Malay Peninsula and Archipelago, Fiji, Java, and Ceylon.)....... **M. vitiensis** (Kirkaldy) ('07: 103).

**Megatrioza armata** Crawford ('15: 264).

The body color of this species is not uniform as indicated in the first description, but the thoracic dorsum has longitudinal bands of brown with pale brownish or yellow-brown between; vertex brown along median suture; forewings clear except an irregular brown area in clavus. The hind wings in this species are long and narrow, about two-thirds as long as forewings, proportionately longer than in most other species of the genus.

This is one of the large species of the genus, probably having a wide distribution as indicated by its being found in two separated portions of the South Pacific Archipelago.

*Type locality.*—Philippine Islands. Occurring also in Borneo—Manorg, West Borneo (*Muir*), 1 male; Sandakan (*Baker*), 1 male.

**Megatrioza armata ochreata** var. nov.

Body a little smaller than the species and slenderer; thorax brown, alternating with a brown or yellow-brown duller than in the species; forewings ochraceous throughout, not clear though nearly transparent; clavus brown. Head similar to the species, except genal cones not longer than vertex; antennæ scarcely more than twice as long as width of head. Thorax similar but slenderer; legs shorter. Forewings narrower, venation similar; hind wings relatively as long as in the species. Male genitalia similar to the species except forceps slenderer than in the species and a little longer than anal valve. Female genital segment not as long as abdomen.

SINGAPORE (*Baker*), 1 pair.

**Megatrioza vitiensis** (Kirkaldy).

*Trioza vitiensis* KIRKALDY, Proc. Hawaiian Ent. Soc. 1 (1907) 103.
*Trioza eugeniæ* CRAWFORD, Philip. Journ. Sci. § D 10 (1915) 265, pl. 1, fig. E, nec Froggatt.

Length of body, 2.6 millimeters; forewing, 5 to 6. General color brown, dorsulum with a pale or yellow central streak and often two lateral ones; mesoscutum with several yellowish or pale longitudinal bands; femora dark brown, tibiæ lighter; antennæ pale yellow, black at tip; forewings clear with a small brown spot at anal angle of both front and hind wings. Color of newly emerged adults usually yellowish or pale brownish yellow, without the markings described above.

Head declivous, not as broad as thorax; vertex about half as long as broad between eyes, sparsely pubescent, deeply impressed on each side of median line, with a transverse sulcus connecting the two foveæ, somewhat convex in anterior half; genal cones about half as long as vertex, broad, rounded, not much divergent, pubescent. Antennæ about one and one-half times as long as width of head. Eyes large.

Thorax strongly arched, rather broad, clothed sparsely with long hairs. Legs long and stout; hind tibiæ stout, with basal spur not very large and apical spines moderately small. Forewings long, about three times as long as broad, acutely pointed, marginal cells very long. Hind wings about half as long as forewings or a little more.

Abdomen short and broad. Male forceps about as long as anal valve or a little shorter, slender, basal two-thirds about three times as long as thick, rounded apically, and distal third abruptly narrowed with a fingerlike process directed inward and acutely pointed; anal valve about as broad as long, lateral

wings broadly convex. Female genital segment very short, much shorter than abdomen, dorsal valve a little longer than ventral, both subacute.

*Type locality.*—FIJI ISLANDS, Rewa (*Muir*), March, 1906, 3 males and 2 females.

SINGAPORE (*Baker*), 1 pair. AMBOINA (*Muir*), 1 female. Pemalonga (*Leeuwen-Reijnvaan*), 1 male and 1 female, on *Eugenia malaccensis*, April 10, 1912. CEYLON, Peradeniya (*A. Rutherford*), 9 males and females from galls on leaves of *Eugenia malaccensis*, May 12, 1913 (described as *Trioza eugeniæ*).

This appears to be a widely distributed species in the South Pacific in tropical Asia, making galls on *Eugenia malaccensis* (known also as *Jambosa domestica*). The name *Trioza eugeniæ*, applied to some newly emerged Ceylonese representatives of this species, was preoccupied by an Australian species named by Froggatt, but subsequent study shows the species to belong to *Megatrioza* and furthermore to be synonymous with Kirkaldy's *T. vitiensis*. The Fiji specimens before me bear no identification mark indicating that they were examined by Kirkaldy, but they agree well with his description of *T. vitiensis* and probably are paratypes in as much as the date of collection and locality are identical in both lots.

**Megatrioza stylata** sp. nov. Text fig. 1.

Length of body, 3 millimeters; forewing, 5 or more. General color brownish yellow to brown; pronotum, medial portion of thoracic dorsum, and abdomen dark brown or black; legs and antennæ yellowish, latter black distad; forewings clear.

FIG. 1. *Megatrioza stylata* sp. nov.

Head strongly descending, narrower than thorax; vertex nearly three times as broad as long, median suture impressed and a foveal depression on each side, sparsely pubescent. Genal cones broad, rounded, more than half as long as vertex, hairy. Antennæ about twice as long as width of head, segments 3 and 4 a little thicker and more setose than following segments.

Thorax very broad and large, sparsely hirsute. Legs stout, hairy; hind tibiæ long with basal spur small and apical spines moderately large. Forewings large, transparent, acutely pointed,

marginal cells long and large. Hind wings about half as long as forewings.

Male forceps long, acuminate, curved, acutely pointed, hairy. Anal valve a little longer than forceps, broadest at base, somewhat triangular in outline, about twice as long as basal width. Female genital segment about half as long as abdomen, dorsal valve a little longer than ventral, both subacute. Ovipositor very slender and acute, styliform, exserted.

SINGAPORE (*Baker*), 1 pair. LUZON, Laguna Province, Mount Maquiling (*Baker*), 1 female.

In wing venation this species is apparently allied closely to *M. vitiensis*.

**Megatrioza asiatica** Crawford.

*Trioza asiatica* CRAWFORD, Philip. Journ. Sci. § D 10 (1915) 266.

This species must be referred to *Megatrioza*, although the basal spur of the hind tibia is almost wanting and the subapical spine is very near the apex. The large anterior metacoxal spurs and the shape and venation of the forewings indicate a close alliance to *Megatrioza* species. The hind wings in this species are remarkable in being reduced to mere stubs that are not at all functional.

This and the following species (*M. magnicauda*) bear a closer similarity to the American *T. diospyri* Ashmead than any other known species, indicating a probable relationship.

MINDANAO, Davao (*Baker*), 1 pair.

**Megatrioza magnicauda** sp. nov. Text fig. 2.

Length of body, 2 millimeters; forewing, 4. General color glossy black; antennæ yellowish, black at tip; legs black, hind tibiæ yellowish or whitish on basal two-thirds; forewings clear, a black spot in clavus.

Head and thorax similar to *M. asiatica*, to which this species is closely related, but distinctly narrower; genal cones a little shorter and directed more downward than forward; antennæ a little shorter. Forewings relatively a little broader and marginal cells shorter and broader; hind wings reaching to end of abdomen, while in the related species they scarcely reach half way there.

FIG. 2. *Megatrioza magnicauda* sp. nov.

Male forceps similar, but anal valve immense, reaching caudad beyond forceps, rectangular in outline with anal opening much

elevated. Female genital segment longer and more acutely pointed.

LUZON, Mount Limay (*Baker*), 1 pair.

This is obviously close to *M. asiatica* but appears to be a distinct species.

**Megatrioza eugenioides Crawford.**

*Trioza eugenioides* CRAWFORD, Philip. Journ. Sci. § D 12 (1917) 171.

Length of body, 2 millimeters; forewing, 4. General color chocolate brown with orange yellow markings; vertex flavous; dorsulum brown with a flavous stripe down center and flavous borders; mesoscutum with several tawny stripes and bands; legs except hind femora and antennæ except at tip yellowish; forewings clear with a black spot in clavus.

Head nearly as broad as thorax, only a little declivous; vertex about half as long as broad, with a deep, brown, foveal depression on each side of median line; anterior ocellus in front; genal cones directed downward, about half as long as vertex, narrowly rounded at apex. Antennæ very slender, about one and one-half times as long as width of head.

Thorax somewhat arched, reticulately marked, sparsely pubescent. Hind tibiæ with two small spurs at base close together, subapical spines moderately large. Forewings clear, very transparent; hind wings a little more than half as long as forewings.

Female genital segment very short, bluntly pointed.

MINDANAO, Butuan (*Baker*), 3 females. INDIA, Pusa, Bihar (*Misra*), 1 female taken on the wing, January 26, 1914. BORNEO, Sandakan (*Baker*), 1 female. The last specimen differs slightly from the others in being less pubescent on the dorsum. This species appears to be a widely distributed one and may prove to be identical with some already-known species of *Trioza*.

**Megatrioza vanuæ (Kirkaldy).**

*Trioza vanuæ* KIRKALDY, Proc. Hawaiian Ent. Soc. 1 (1907) 104.

Length of body, 2 millimeters; forewing, 3.2. General color yellowish to light brown, abdomen brown to black on basal half, reddish brown caudad; vertex light brown, with a narrow black line down center. Dorsum very sparsely hairy.

Head nearly as broad as thorax, broader than prothorax, not strongly deflexed; vertex only slightly impressed on either side of median line, postocelli scarcely elevated; genal cones short, broadly rounded, not half as long as vertex. (Antennæ broken off at base.)

Thorax not broad nor much arched; pronotum somewhat de-

pressed and with projecting episternum (dorsal aspect) appearing somewhat like a collar. Legs moderately long, femora stout; hind tibiæ with an inconspicuous spur at base and a prominent spiniform tooth near apex. Forewings long and slender, three times as long as broad, acute at apex, wholly hyaline, marginal cells about equal in size, radius short. Hind wings about half as long as forewings, very narrow and delicate.

Female genital segment short, not longer than preceding tergite, with an abruptly acute apex.

FIJI ISLANDS, Rewa (*Muir*), March 3, 1916, 1 female. LUZON, Laguna Province, Mount Maquiling (*Baker*), 1 male doubtfully of this species. The latter specimen is so imperfectly preserved that its identity is a matter of doubt, but it appears to represent this species. The forceps are nearly as long as anal valve, triangular in lateral aspect, about three times as long as basal width, acutely pointed. Anal valve with caudal margin somewhat sinuate, bulging caudad midway.

The specimen from Fiji bears the same date of collection as that examined by Kirkaldy, but there is no indication that he had examined it.

**Megatrioza gigantea** sp. nov.

Length of body, 3.6 millimeters; forewing, 4.3. General color brown and orange yellow; vertex yellowish, brown on posterior portion; thoracic dorsum variegated with brown and dull yellow; pleuræ yellowish; abdomen mostly brown; femora brown but remainder of legs yellowish; antennæ reddish, black at tip; eyes brown; forewings clear with black spot on anal angle.

Head nearly as broad as thorax, about 1 millimeter wide, somewhat declivous; vertex hirsute, about half as long as broad, nearly rectangular in outline, with median suture depressed and a prominent sulcus on each side connected by a transverse, slightly impressed, black line near middle of vertex. Genal cones declivous, thick, about half as long as vertex, bluntly rounded distad. Antennæ a little more than twice as long as width of head, slender.

Thorax very large and broad, well arched, slightly hirsute. Legs stout, hirsute; hind tibiæ with two basal spurs, a large subapical spine and three large apical spines. Forewings very large, acute apically, veins thin, membrane delicately transparent.

Abdomen short and thick. Female genital segment short, dorsal valve a little longer than ventral, bluntly rounded. Ovipositor sheath heavy and conspicuously serrate.

PENANG (*Baker*), 1 female.

Megatrioza robusta sp. nov.

Length of body, 3 millimeters; forewing, 5.1. General color brown and dull yellow; pronotum brown; meso- and metanotum alternating brown and dull yellow streaks; abdomen mostly brown; legs and antennæ yellowish, latter brown at tip; forewings clear, with a small black spot on anal angle.

Head considerably narrower than thorax, declivous; vertex sparsely hirsute, about half as long as broad, front and hind margins subparallel, arcuate forward, with a foveal depression on each side of median line. Genal cones nearly or quite as long as vertex, slightly declivous, broad at base, subacutely pointed. Antennæ scarcely twice as long as width of head.

Thorax very broad and robust, sparsely hairy, finely impunctate; legs rather short and stout; hind tibiæ with small spurs at base, apical and subapical spines moderately large. Forewings large, clear, acutely pointed. Hind wings about half as long as forewings, narrow.

Abdomen short and thick. Female genital segment short, dorsal valve a little longer than ventral, both subacute.

LUZON, Mount Banahao (*Baker*), 1 female.

Megatrioza melanoneura sp. nov.

Length of body, 3 millimeters; forewing, 5. General color dark brown to black; vertex, genæ, thoracic pleuræ, hind tibiæ, and antennæ all dull reddish yellow; antennæ and hind tibiæ black distad; forewings clear, with a black spot on anal angle and a black band following basal vein along radius to costal margin.

Head narrower than thorax, declivous. Vertex about half as long as broad, sparsely hairy, bulging roundly in front, with a transverse depression extending from in front of posterior ocelli arcuately toward occipital margin of head. Genal cones declivous, about half as long as vertex, bluntly rounded, hairy. Antennæ about one and one-half times as long as width of head.

Thorax broad, well arched, sparsely hairy. Legs thick, very hairy; hind tibiæ with small basal spur, a moderately large subapical spine and two apical spines. Forewings large, transparent, veins narrow and black; basal and radial veins conspicuous by the black border. Hind wings about half as long as forewings.

Abdomen large and thick. Male forceps about as long as anal valve, slender, arched and subacutely pointed. Anal valve moderately long, about one-third as broad at base as long, nar-

rowing toward apex. Female genital segment about three-fifths as long as abdomen, converging to an acute point, dorsal valve a very little longer than ventral.

LUZON, Mount Banahao (*Baker*), 1 male; Benguet Subprovince, Baguio (*Baker*), 1 female.

Megatrioza hirsuta Crawford.

*Kuwayama hirsuta* CRAWFORD, Rec. Indian Mus. 7 (1912) 427, pl. 33, figs. V, Y; pl. 35, fig. I.

With additional material of this species available for comparison, it now appears that it must be referred to *Megatrioza*. The wing venation, the spurred hind tibiæ, the anterior metacoxal projections, and the gall-forming habit, all relate this undoubtedly to this genus rather than to *Kuwayama*, in which it was first placed with much hesitation. The genæ are scarcely swollen beneath the vertex and not at all conical, but there is a strong tendency in *Megatrioza* toward the suppression of the genal cones. The large size and the hairy head and thorax make this a striking species.

INDIA, Lonavla, Bombay (*H. H. Mann*), 1 male, in galls on *Terminalia tomentosa*, July, 1916.

## Genus CEROTRIOZA Crawford

Head scarcely declivous, rather long; vertex produced in front into two hornlike epiphyses; genæ produced into cones directed forward; antennæ slender. Thorax not strongly arched, narrow; hind tibiæ with small basal spur or callus and subapical spine (as in *Megatrioza*). Forewings narrow, opaque or semiopaque, maculated, first marginal cell usually larger than second; hind wings nearly as long as forewings.

Type of the genus, *Cerotrioza bivittata* Crawford ('18: 454).

This genus appears to be related to, probably sprung from, *Megatrioza* but differs sharply in the thickened and semiopaque forewings and peculiarly shaped vertex. The type species is one found in the Hawaiian Archipelago.

*Key to the species.*

*a*¹. Genæ produced into more or less conical processes directed forward, without dark vitta on each side of body.

*b*¹. Length of insect to tip of folded wings about 3 millimeters; color dark brown; vertex horns nearly half as long as genal cones. (Singapore.) ........ C. corniger sp. nov.

*b*². Length to tip of folded wings about 4 millimeters; vertex horns much smaller. (Borneo.) ........ C. microceras sp. nov.

$a^2$. Genæ not produced into conical processes, but somewhat spherically swollen beneath antennal bases and protruding vertex; with a prominent dark vitta on each side of head and thorax and extending to tip of each forewing. (Hawaii.)

C. bivittata Crawford ('18: 454).

Cerotrioza corniger sp. nov. Plate III, fig. 12.

Length of body, 1.9 millimeters; forewing, 2.6. General color brown, mottled and banded with yellowish white; vertex with margins and median suture bordered with dirty white; pronotum with three whitish points; notum of thorax with irregular stripes and bands of dirty white; abdomen mostly dark brown; legs yellowish, femora with brown spots; antennæ pale brown.

Head slightly declivous, as broad as thorax; vertex about three-fifths as long as broad between eyes, with a relatively large foveal depression on each side of median line, anterior horns situated over genal cones and about half as long as latter, acute and upturned; front ocellus visible from above; genal cones about half as long as vertex, directed forward, divergent, bluntly pointed, scarcely hairy. Antennæ about one and one-half times as long as width of head, slender.

Thorax narrow. Legs long and slender, especially the tibiæ; hind tibiæ with very small basal spur and a larger, black subapical spine. Forewings nearly opaque, membrane thickened and whitish or pale brownish with numerous small, dark brown spots all over; broadest subapically but the apex abruptly acutely pointed; first marginal cell about twice as large as second.

Abdomen long. Female genital segment nearly as long as abdomen, slender, acutely pointed.

SINGAPORE (*Baker*), 1 female.

Cerotrioza microceras sp. nov. Plate III, fig. 10.

Length of body, 2.2 millimeters; forewing, 3.1. General color grayish white with pale brown markings on mesonotum and pleuræ; legs pale; antennæ yellowish with black tip; abdomen light brown.

Head somewhat declivous, not quite as broad as thorax; vertex about three-fourths as long as broad, with an irregular star-shaped depression on each side of median line, a pair of small epiphyses in front adjoining median suture and a larger pair outside of these, the latter scarcely one-fourth as long as genal cones; front ocellus visible from above. Genal cones a little more than half as long as vertex, divergent, bluntly pointed, directed forward, somewhat pubescent. Antennæ a little more than twice as long as width of head.

Thorax narrow, somewhat arched; legs not as long as in related species; hind tibiæ with distinct basal spur and large subapical spine. Forewings nearly opaque, membrane thickened and whitish, with numerous small, light brown spots all over. Shaped as in related species, but apex more pointed.

Abdomen long. Female genital segment as long as abdomen, acutely pointed, slender.

WEST BORNEO, Mowong (*Muir*), 1 female.

### Genus STENOPSYLLA Kuwayama

Head declivous, not as broad as thorax; genæ produced into conical processes, not covering frons completely but nearly so; clypeus subspherical; beak of median length. Antennæ long, very thick and thickly pubescent. Eyes large. Thorax broad; legs stout; hind tibiæ with basal spur and subapical spine and several apical spines. Forewings large, hyaline, triozine in venation, radius very long.

Type of the genus, *Stenopsylla nigricornis* Kuwayama.

This genus bears some resemblance to *Bactericera* but differs in the very pubescent antennæ and presence of genal cones. In the armature of the hind tibiæ there is a close similarity to *Megatrioza*.

*Key to the species.*

$a^1$. Body yellowish or light brown, dorsum flecked with brown; genal cones acutely pointed; antennæ half as long as forewings; insect about 5 or 6 millimeters long. (Formosa.)
S. nigricornis Kuwayama ('10: 54).

$a^2$. Body light brown, dorsulum and vertex black or dark brown; genal cones broadly rounded at apex; antennæ three-fourths as long as forewings; insect 6 to 7 millimeters long. (Philippines.)
S. longicornis sp. nov.

**Stenopsylla longicornis** sp. nov. Text fig. 3.

Length of body, 4 millimeters; forewing, 6; antennæ 4.5. Dorsulum and eyes dark brown or black; vertex, mesoscutum and abdominal notum brown; rest of body orange yellow to light brown; antennæ brown to black; legs orange yellow.

Head much narrower than thorax, strongly declivous; vertex smooth, broadly concave, about half as long as broad, median suture longer than lateral edges, without foveal depressions. Genal cones nearly as long as vertex, directed vertically downward, broad and bluntly rounded, divergent, sparsely hairy. Frons slightly visible at front ocellus. Antennæ about five times as long as width of head segments 1 and 2 short and thick,

not hairy; 3 and 4 as thick as 2 and densely covered with stiff setæ set on tiny tubercles; 5 to 10 gradually becoming more slender, about half as thick at tip as segment 3, all uniformly densely setose.

Thorax very broad, well arched, surface smooth and glossy. Legs short and stout; hind tibiæ a little longer than femora, with a moderately large basal spur and large distal spines.

FIG. 3. *Stenopsylla longicornis* sp. nov.

Forewings large, acutely pointed, hyaline, veins heavy, costa setose; radius very long; first marginal cell much larger than second.

Abdomen stout. Female genital segment about half as long as abdomen, dorsal valve a little longer than ventral, subacute, descending.

LUZON, Laguna Province, Mount Maquiling (*Baker*), 1 female.

This appears to be very close to the Formosan species of the same genus, but is a larger insect and differs structurally as well as in coloration.

BIBLIOGRAPHY

The following bibliographical list is by no means a complete one. A more nearly complete list may be found in my monograph, 1914. Only the works referred to in the preceding pages are listed below:

CRAWFORD, D. L.:

'12 Indian Psyllidæ. *Rec. Indian Mus.* 7 (1912) 419–437.

'13 New genera and species of Psyllidæ from the Philippine Islands. *Philip. Journ. Sci.* § D 8 (1913) 293–301.

'14 A Monograph of the Jumping Plant Lice (Psyllidæ) of the New World. *Bull. U. S. Nat. Mus.* 85 (1914) 1–186.

'15 Ceylonese and Philippine Psyllidæ. *Philip. Journ. Sci.* § D 10 (1915) 257–269.

'17 Philippine and Asiatic Psyllidæ. *Philip. Journ. Sci.* § D 12 (1917) 163–177.

'18 The jumping plant lice of the Hawaiian Islands. *Proc. Hawaiian Ent. Soc.* 3 (1918) 430–457.

FROGGATT, W. W.:
'00 Australian Psyllidæ. *Proc. Linn. Soc. New South Wales* 25 (1900) 250–302, pls. 9–14.
'01 Australian Psyllidæ. Part II. *Proc. Linn. Soc. New South Wales* 26 (1901) 242–298, pls. 14–16.
'03 Australian Psyllidæ. Part III. *Proc. Linn. Soc. New South Wales* 28 (1903) 315–338, pls. 4 and 5.

KIRKALDY, G. W.:
'07 On two new Vitian Chermidæ. *Proc. Hawaiian Ent. Soc.* 1 (1907) 103 and 104.
'08 A catalogue of the Hemiptera of Fiji. *Proc. Linn. Soc. New South Wales* 33 (1908) 345–390.

KUWAYAMA, S.:
'08 Die Psylliden Japans I. *Trans. Sapporo Nat. Hist. Soc.* 2 (1908) 149–189.
'10 Die Psylliden Japans II. *Trans. Sapporo Nat. Hist. Soc.* 3 (1910) 53–66.

RÜBSAAMEN, E. H.:
'99 Gallen aus Europa, Asien, Afrika und Amerika. *Ent. Nachricht.* 25 (1899) 225–281.

166470——6

# ILLUSTRATIONS

## Plate I



## Plate II



## Plate III



## TEXT FIGURES

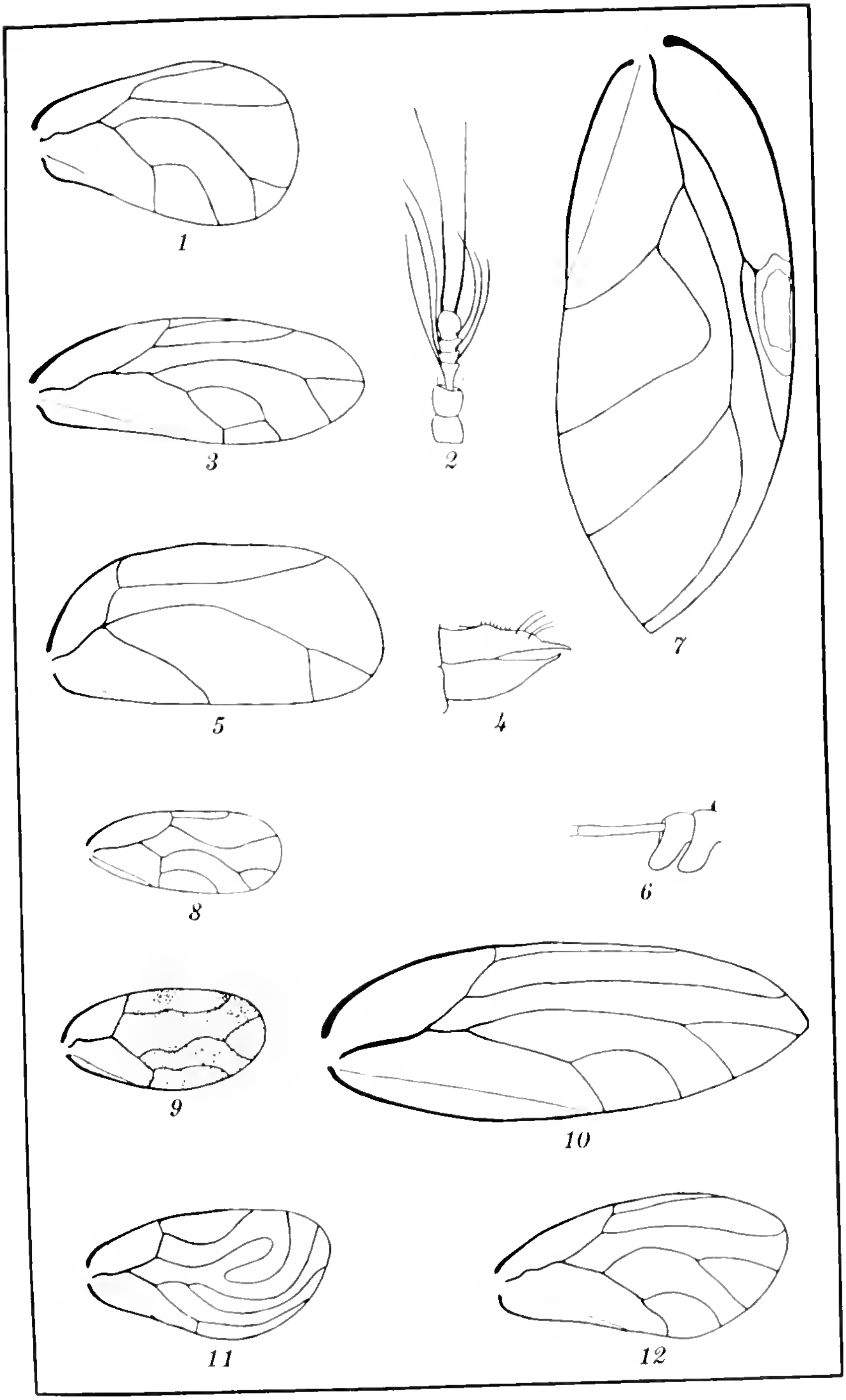



PLATE I. NEW PSYLLIDÆ.

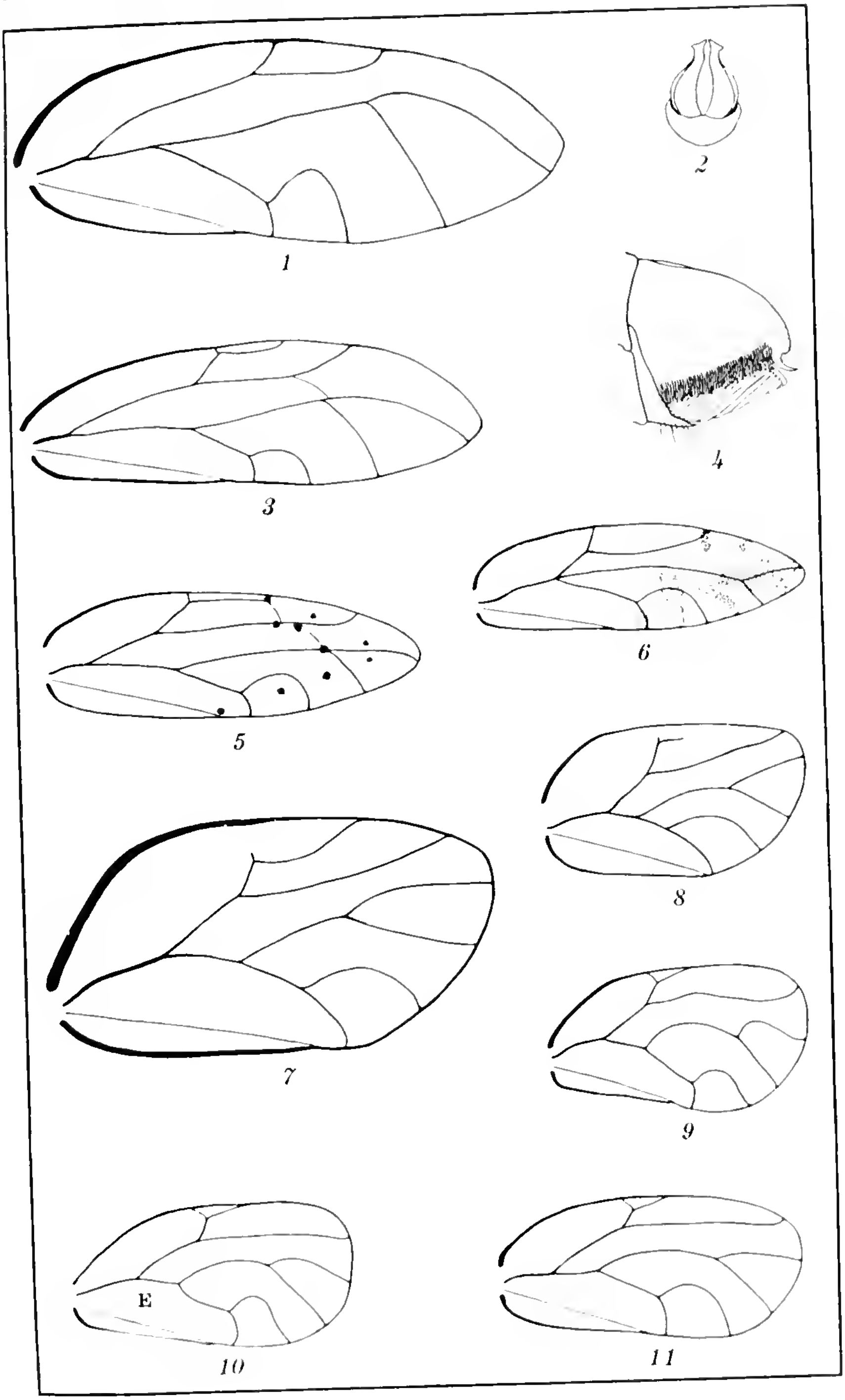



PLATE II. NEW PSYLLIDÆ.

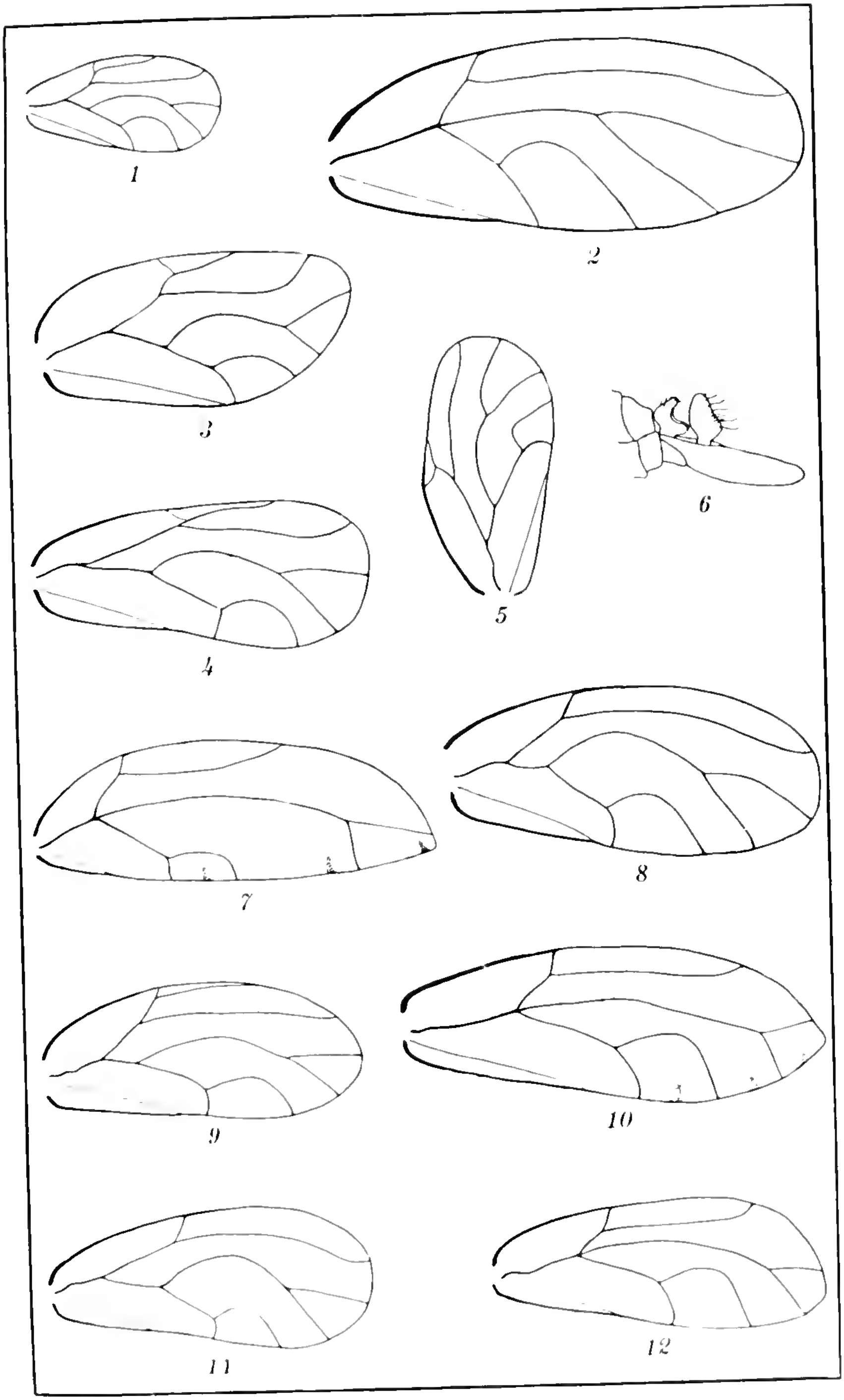



PLATE III. NEW PSYLLIDÆ.

# THE GENUS KRISNA (JASSIDÆ)

By C. F. Baker

*Of the College of Agriculture, University of the Philippines, Los Baños*

FIVE PLATES

The Orient possesses an extensive fauna of large, fine jassoid insects related to *Selenocephalus*. These are all stout-bodied, short-headed jassids and commonly with the face, or the vertex, or the pronotum, or all three, coarsely sculptured, this sculpturing commonly consisting of transverse rugosities or wrinkling, and frequently with the clavus and the base of the corium strongly punctate or rugose-punctate. The anterior border of the head varies from sharp margined to very obtusely rounded between the vertex and the face.

In general, the jassids in question are distinguished by two important structural characters. The antennal scrobes are large, and not confined to the cheek, but involve a portion of the lateral surface of the frons, and are overhung by a thick, sharp, margined ledge, which passes on to the frons, the carinate edge curving downward on the latter, in some cases nearly to the clypeus. The lateral margin of the frons thus passes upward through the scrobe and cuts the supra-antennal ledge. Neither previous descriptions nor drawings bring out this important structural feature, and previous drawings of the face are uniformly incorrect as to this area. The ocelli are on the upper anterior border of the head or near it, near to the eyes, and often visible from above. The actual superior frontal border is just below the ocelli; this suture is rarely distinct, though frequently rudimentary at the sides. The anterior border of the head may be margined by a more or less sharp transverse carina above the ocelli, and at the same time may have another similar carina just below the ocelli, in which case we say that the ocelli lie in a transverse furrow or sulcus. Either one or both of these carinæ may be absent or there may be several sharp transverse carinæ. Sometimes the sulcus is very narrow; at other times, broad with a few to many transverse wrinkles within. Sometimes both carinæ are lacking, and only the transverse band of wrinkles remains. But the wrinkles or the carinæ or the sulcus, in some form, are always present in the members of this group. The

superior frontal margin thus always lies below the apparent upper anterior border of the head, which may not be at all extended above and cephalad of the superior frontal suture, or may be strongly so as in the Tartessusaria. Some of these insects possess a superficial resemblance to bythoscopids, and Walker wrongly described various species of *Tartessus* and other genera in *Bythoscopus*. But in all, including *Tartessus*, the ocelli are far higher and very close to the eyes, and this and other characters mark them as true jassids. In superficial habitus *Krisna* presents a very remarkable resemblance to *Gypona*, so much so that Kirkaldy described a new genus, *Eogypona*, in the Gyponinæ, for one of its species. It has, of course, not the remotest relationship to *Gypona*. In addition, the true Gyponinæ (excluding the Penthimiinæ) are exclusively American.

A minor character common to this assemblage may be observed in the loræ, the suture of which, above, usually does not reach the frontal suture, but commonly ends in a more or less radiate arrangement of minute wrinkles some distance from the frontal margin. In rare cases this suture is subobsoletely extended and strongly recurved to the lateral frontal margin, making the lora ear-shaped. Previous drawings, even those of Signoret, are incorrect in this detail of structure.

The jassids discussed above fall into three tribes as follows:

*Key to the tribes.*

$a^1$. Head as wide as or wider than pronotum; frontoclypeal suture usually distinct; lateral pronotal carina very short.

- $b^1$. Pronotum strongly, narrowly rounded cephalad, and extending beyond anterior margin of eyes; ocellar area broad and usually transversely wrinkled; appendix of tegmina usually extending around apex, and very broad apically, rarely wanting as in *Macroceps*; ovipositor long, exserted; *Pediopsis*-like in form .......... Tartessusaria.
- $b^2$. Pronotum not extended cephalad of anterior margin of eyes; ocellar area narrow, usually once or several times sulcate; appendix of tegmina usually extending only to apex or less, and broadest subapically; ovipositor little exserted .......... Selenocephalaria.

$a^2$. Head distinctly narrower than pronotum; frontoclypeal suture obsolete or subobsolete; ocellar area broad and transversely wrinkled and with one or more transverse carinæ above it; lateral pronotal carina (and pronotum behind eyes in lateral view) long; ovipositor little or not exserted; *Gypona*-like in form .......... Stegelytraria.

Distant names two of these tribes but gives no diagnostic characters. He places *Krisna* in the Selenocephalaria, but *Gessius*, which might easily be called a subgenus of *Krisna*, he puts in the Tartessusaria. Several genera formerly placed in the Selenocephalaria do not belong in this congeries at all, and a number

of genera formerly classified elsewhere must be removed to it. In fact, some of the species described in *Selenocephalus* do not even belong in the Selenocephalaria. The tribe Tartessusaria includes *Tartessus* Stål, (?) *Borduria* Dist., *Macroceps* Sign., *Putoniessa* Kirk., *Sarpestus* Spang., and *Thymbris* Kirk. Some of these may be synonymous with *Tartessus*. *Drabescus* Stål should be removed to the Selenocephalaria.

The present paper is concerned especially with two genera of the Stegelytraria, the genera of which may be separated as follows:

Tribe STEGELYTRARIA

*Key to the genera.*

$a^1$. Tegmina without distinct appendix; length of tegmina beyond clavus about one-third length of clavus.

  $b^1$. Vertex anteriorly horizontally rounded; anterior pronotal margin arched, posterior margin slightly emarginate; tegmina with two subapical cells.......... **Stegelytra M. and R.**

  $b^2$. Vertex anteriorly subangulate; pronotum anteriorly subtruncate between eyes, posteriorly subtruncate between scutellar angles; tegmina with four subapical cells.......... **Iberia Kirk.**

$a^2$. Tegmina with a well-developed appendix; length of tegmina beyond clavus more than half length of clavus.

  $b^1$. Venose portion of tegmina beyond clavus strongly narrowed, the apical cells long and narrow, anterior margin of pronotum broadly rounded between eyes; frons medially never carinate and always much broader than width of eye in facial view.

    $c^1$. Tegmina apically with numerous supernumerary veins (Plate I, figs. 1, 3, and 5).......... **Krisna Kirk.**

    $c^2$. Tegmina apically normally without supernumerary cross veins (Plate V, fig. 1).......... **Gessius Dist.**

  $b^2$. Venose portion of tegmina beyond clavus not narrowed, the apical cells broad in proportion to length; anterior margin of pronotum narrowly rounded between eyes; frons medially carinate; distance between eyes subequal to width of eye in facial view. **Cœlidioides Sign.**

## Genus KRISNA Kirkaldy

A common evening visitor to one's table lamp, almost anywhere in the Malaisian countries, is a vividly virescent leafhopper of the genus *Krisna*, a half inch, more or less, in length, and with the transverse fore margin of the vertex black or a bright reddish color. This is likely to be *Krisna strigicollis*, but other species frequently occur. These insects were known for many years under the generic name *Sira* Spinola,[1] but that name being preoccupied, Kirkaldy [2] renamed the genus *Krisna*.

[1] Mem. di Matem. e di Fis. Soc. Ital. Modena (1852) 167.
[2] Entomologist 33 (1900) 243.

The type species of the genus as described by Spinola was *Siva strigicollis*, now supposed to be widely distributed through the Orient. In 1891 Kirby [3] described *striata* from Ceylon, though neither Kirby nor other authors have given diagnostic characters to distinguish it clearly from *strigicollis*. In 1908 Distant [4] described *Krisna sherwilli* from Sylhet, actually separating it on color characters only, which are extremely unstable in this genus, the structural characters mentioned being entirely generic in value or without diagnostic significance. In 1910 Bierman [5] described a *Siva rosea* from Java. Here again most of the structural characters mentioned are only generic in value. Long ago, Walker indicated three species now recognized as pertaining to *Krisna;* namely, *Acocephalus stramineus*,[6] *Bythoscopus indicatus*,[7] and *Bythoscopus testaceus*.[8] Distant refers all of these to *Krisna strigicollis*, but since no author has previously described the diagnostic structural characters of *strigicollis*, and since it is entirely probable that under insufficient description several distinct things have been referred to *strigicollis*, all of this synonymy will have to be reëxamined. In 1901 Breddin [9] attempted to define a *Krisna straminea* Wlk. var. *indicata* Wlk., from Celebes, thereby adding to the usual Walkerian uncertainty, since practically his entire description is composed of generic characters. Several species of the genus have also been described from Africa.

This genus includes a very homogeneous group of species, the form and markings of all being very similar. The vividly virescent species commonly fade to stramineous in dried specimens, and carmine markings usually entirely disappear. When deep olive green or some shade of rufous the color may not change in drying, though in life there is wide variation in the shade of rufous. The black dot at the apex of the clavus is quite constant in most of the species, but the black markings on the vertex are very inconstant, sometimes varying in the same species from a narrow continuous black stripe near the fore margin to separated spots at the middle and sides, and even these may be absent. Specimens of green species may occur with a strong pinkish or reddish tinting.

[3] Journ. Linn. Soc. Zool. 24 (1891) 171.
[4] Fauna Brit. India, Rhynch. 4 (1908) 299.
[5] Notes Leyden Mus. 33 (1910) 61.
[6] List. Hom. 3 (1851) 847.
[7] List. Hom. Suppl. (1858) 266.
[8] Journ. Linn. Soc. Zool. I (1857) 173.
[9] Abh. Naturf. Ges. Halle 24 (1901) 130.

All of this means that no sound classification of the species (as in most jassids) can be based on colors, but that detailed study must be made of all important features of the external anatomy. Nor does it avail in the least to build up species descriptions by repeating characters common to all or even part of the species in the genus. All of these species are long oval in outline and strikingly gyponoid in form, with the vertex very bluntly angulated or rounded between the eyes (it may be quite different in the sexes); the face and the vertex variously rugose and wrinkled; the pronotum, except anteriorly, thickly and finely cross striate; the scutellum having a strongly curved discal furrow, before which the surface is rugose, behind it, cross wrinkled; and the tegmina more or less thickly punctate. The number and the position of the supernumerary veins vary in the same species. The pronotum always possesses a long, strong, complete lateral carina. The frons is thickly rugose of varying degrees of coarseness. The cheek is slightly roughened below the eye, obliquely wrinkled on the middle third, and rugose below. The clypeus and the loræ are more or less rugosely roughened. The size is variable within narrow limits in all of the species.

*Key to the species of Krisna.*

*a*¹. Lower margin of transversely wrinkled ocellar area with several strong, irregular, noncontinuous wrinkles of similar size, and with wrinkles on supra-antennal area; frons below ocellar area not or only moderately depressed; smaller species of slenderer form.

*b*¹. Frons evenly convex from margin of vertex to clypeus; length of male, 8.5 millimeters .......... K. minima sp. nov.

*b*². Frons distinctly depressed below ocellar area; size usually larger.

*c*¹. Vertex with but one irregular submarginal carina, distinct at least at sides, the entire disk uniformly coarsely rugose.

*d*¹. Supra-antennal carina passing on to frons in an even curve, or for a short distance straight and then curved; tegmina translucent, the puncturation rather fine.

*e*¹. Lateral carina of pronotum about same length as eye in lateral view.

*f*¹. Supernumerary veins numerous; wings milky subhyaline; face concolorous with remainder of undersurface.
K. strigicollis Spin.

*f*². Supernumerary veins few; wings dark smoky.

*g*¹. Supra-antennal area as broad as long, face concolorous.
K. simillima sp. nov.

*g*². Supra-antennal area longer than broad; frons black.
K. nigrifrons sp. nov.

*e*². Lateral carina of pronotum distinctly longer than eye in lateral view .......... K. penangensis sp. nov.

*d'*. Supra-antennal carina sharply angled where it crosses frontal suture, from this point passing straight cephalad for a short distance; tegmina thickly coriaceous, opaque, the puncturing very coarse.

*e'*. Transverse wrinkles numerous on face above, and fine and regular; supra-antennal area with about ten small wrinkles between its lower point and the ocellus ..... K. muirii sp. nov.

*e²*. Transverse wrinkles few on face above, and coarse and irregular; supra-antennal area with about five large wrinkles between its lower point and the ocellus.
K. olivascens sp. nov.

*c²*. Vertex with a series of about four submarginal carinæ, the posterior incomplete, together occupying about one-half of vertex, the posterior portion of disk rugose; otherwise like the species.
K. olivascens var. singaporensis var. nov.

*a²*. Lower margin of transversely wrinkled ocellar area with a strong, uniform, transverse carina, without or with very few weak wrinkles below it, and with the wrinkles above it much weaker; supra-antennal area smoothly concave; frons below ocellar area strongly deeply depressed, and with three large smooth foveate areæ above; puncturation of tegmina minute, weak, sparse, most evident along veins; vertex without a submarginal carina near anterior marginal carina.

*b'*. Disk of pronotum very strongly arched; color pale virescent; wings milky subhyaline ..... K. magna sp. nov.

*b²*. Disk of pronotum very weakly arched; tegmina carmine basally; wings deep smoky ..... K. colorata sp. nov.

Krisna minima sp. nov.[10] Plate I, fig. 2; Plate II, fig. 8; Plate III, figs. 3 and 6.

Length, male, 8.5 millimeters. Pale stramineous dry, but doubtless virescent in life. No dark spot at apex of clavus and no dark markings on head. Vertex anteriorly margined with carmine. Similar to *K. strigicollis* but very much smaller.

LAPPA ISLAND, Macao (*F. Muir*).

Krisna strigicollis Spinola. Plate I, figs. 1, 5, 6, and 8; Plate II, figs. 7 and 9; Plate III, fig. 10; Plate IV, figs. 6 and 12.

Length, female, 12 millimeters; male, 10 millimeters. Pale stramineous dry, but vividly virescent in life, with vertex anteriorly bordered more or less broadly with carmine, and with a submarginal black stripe, which is often obsolete on middle of sides, leaving two black dots near margins of eyes and two near median line, but these also may be obsolete. Wings usually milky subhyaline. Last ventral segment of female behind truncate to more or less broadly angularly emarginate.

[10] Characters given in the synopsis are not repeated in the descriptions.

A common species in the Malay Peninsula, Singapore, Borneo, and the Philippines. I also have a specimen taken in Java by Mr. F. Muir.

**Krisna simillima** sp. nov. Plate II, fig. 2; Plate III, fig. 11; Plate IV, figs. 7 and 9.

Length, female, 11 millimeters. Rufous-stramineous; a submarginal dark dot on either side of vertex near eye margins. Wings smoky. Last ventral segment subtruncate posteriorly.

BORNEO, Sandakan (*Baker*). Larger series may prove this to be an extreme variety of *K. strigicollis*.

**Krisna nigrifrons** sp. nov. Plate I, fig. 4; Plate II, fig. 10; Plate III, fig. 2; Plate IV, fig. 10.

Length, male, 9 millimeters. Rufous-stramineous. Vertex marked as in *K. strigicollis*. Disks of frons, clypeus, and loræ black.

SINGAPORE (*Baker*).

**Krisna penangensis** sp. nov. Plate II, fig. 4; Plate III, fig. 8; Plate IV, figs. 5 and 11.

Length, female, 11 millimeters. Pale rufous above, stramineous below, vertex marked as in *K. strigicollis*. Three inner apical cells of tegmina transparent, remainder opaque. Wings smoky. Last ventral segment truncate posteriorly.

PENANG (*Baker*).

**Krisna muirii** sp. nov. Plate I, fig. 7; Plate III, figs. 13 and 15; Plate IV, figs. 2 and 8.

Length, female, 12 millimeters. Clear rufous above, stramineous below. Vertex with a submarginal fine uniform dark line. Tegmina thickly coriaceous and strongly punctured throughout, the appendix smoky and the inner apical cells stained with smoky. Face with a dark arcuate stripe passing across middle of cellar area. Last ventral segment somewhat angularly emarginate posteriorly.

WESTERN BORNEO, Telok Ayer (*Muir*).

**Krisna olivascens** sp. nov. Plate I, fig. 3; Plate II, fig. 6; Plate III, figs. 5 and 9; Plate IV, fig. 4.

Length, female, 13 to 14 millimeters; male, 11 millimeters. Deep olive green above, scutellum, anterior portion of pronotum, and vertex paler; below stramineous, tibiæ more or less carmine, the foretibiæ with angular edges black. Vertex an-

teriorly narrowly margined with black, this margined behind with carmine; face above with a submarginal narrow black line, this again margined below with carmine. Tegmina thickly coriaceous, very strongly punctured, the appendix smoky, and some of the inner apical cells stained with smoky. Hind margin of last ventral segment incurved.

This very fine species is not uncommon in Singapore and Penang; and I have specimens from Sandakan, British North Borneo.

A remarkable variety of this species, from Singapore, has the vertex quite differently sculptured, and it is somewhat paler in color, but otherwise similar to the typical form. I call it var. singaporensis var. nov.

**Krisna magna** sp. nov. Plate II, figs. 3 and 5; Plate III, figs. 1, 4, 12, and 14; Plate IV, fig. 3.

Length, female, 14 millimeters; male, 13 millimeters. Distinct from all other oriental species in the genus by its very robust form, the body being very thick, and very strongly arched across base of pronotum. Very pale virescent above, stramineous below. Vertex anteriorly with two minute black dots next to eyes. No spot at apex of clavus. Wings milky subhyaline. Sexes strikingly different in form of head.

Specimens come from Penang Island and from Sandakan, British North Borneo, though apparently the species is not common. This is the largest known oriental species of the genus.

**Krisna colorata** sp. nov. Plate II, fig. 1; Plate III, fig. 7; Plate IV, fig. 1.

Length, female, 13 millimeters. Anterior portion of pronotum, vertex, and all below stramineous; pronotum posteriorly and scutellum pale rufous. Tegmina smoky subhyaline, veins and basal two-thirds washed with carmine. Wings deep smoky. Vertex with a marginal line of carmine, and two large black dots near eye margins. Last ventral segment with the margin broadly scarious.

BRITISH NORTH BORNEO, Sandakan (*Baker*).

### Genus GESSIUS Distant

There is no question of the very close relationship of this genus to *Krisna;* the venation of the tegmina furnishes the only real means of separating them and even this shows close relationship, in as much as occasional abnormal supernumerary veins

occur in *Gessius*. Here are included some common insects of the Malay Peninsula, Borneo, and the Philippines, which I have no doubt were frequently collected previously; and specimens will probably be found in collections placed with *Krisna*, especially *Krisna strigicollis*.

Among these insects there is a most confusing variation of color shades from bright rufous to stramineous (virescent). All specimens in a large series of several species and varieties possess an unmarked vertex with at most a crimsoned anterior margin, a dot at the apex of the clavus, the wings more or less smoky, the dorsum more or less crimsoned, and all below stramineous. The three or four inner apical cells of the tegmina are subhyaline and impunctate, in strong contrast to the remainder of the tegminal surface.

General sculpturing very similar to that of *Krisna* and similarly distributed.

In all of my material I have no specimens with "the claval area fuscescent, this color longitudinally continued to apex of tegmina" as described by Distant for the type of the genus, *G. verticalis*, from Burma.[11] Is it possible that this fuscescent area is due to the color of the smoky wings beneath?

*Key to the Malayan species.*

$a^1$. Transverse wrinkles of ocellar area confined to a space twice the width of an ocellus, the frons suddenly depressed below this, and irregularly rugose; supra-antennal area smooth.................... **G. malayensis sp. nov.**

$a^2$. Entire upper part of face, down to lower margin of supra-antennal ledges, including supra-antennal areæ, with coarse uniform wrinkles; frons scarcely depressed................................................ **G. pallidus sp. nov.**

**Gessius malayensis** sp. nov. Plate V, figs. 1, 2, 5, 7, 10, and 12.

Length, female, 10.5 millimeters; male, 9 millimeters. Above clear shining pale rufous (variable), below stramineous. The form of the last ventral segment in the female is distinctive, it being deeply, broadly, angularly emarginated, the sides of the emargination sharply notched. Wings very dark veined.

A common species in the Malay Peninsula and Borneo.

A closely similar form is found in Butuan, Mindanao, and in Basilan, which differs only in that the lateral notches in the emargination of the female segment are uniformly shallow and reduced to a strong sinuation. This form may be known as var. **mindanaensis** var. nov.

[11] Fauna Brit. India, Rhynch. 4 (1908) 302.

**Gessius pallidus** sp. nov. Plate V, figs. 3, 4, 9, and 13.

Length, female, 10 millimeters; male, 8.5 millimeters. Above stramineous (in life) to pale virescent; veins of wings pale. The truncate last ventral segment of female is distinctive for the typical form of this species. It is the analogue of *Krisna strigicollis* but smaller and slenderer.

SINGAPORE (*Baker*), frequent.

A form very closely similar to this in every way, except that the hind margin of the last ventral segment of the female is shallowly sinuate, occurs commonly at Sandakan, British North Borneo. I name this var. **sinuatus** var. nov.

Another variety, collected at Telok Ayer, Western Borneo, by Mr. F. Muir, is pale rufous above, and has the hind margin of the last ventral segment of the female distinctly incurved, and this may be known as var. **incurvatus** var. nov.

In my Singapore material I have one male specimen, only 8.5 millimeters long, which I cannot separate structurally from the typical form, but which is very dark sordid rufous above, with apical third of tegmina pale. I name this var. **suffusus** var. nov. (Plate V, figs. 6, 8, and 11).

# ILLUSTRATIONS

## PLATE I

FIG. 1. *Krisna strigicollis* Spin., forma; tegmen.
2. *Krisna minima* sp. nov., head and pronotum.
3. *Krisna olivascens* sp. nov., tegmen.
4. *Krisna nigrifrons* sp. nov., head and pronotum.
5. *Krisna strigicollis* Spin., wing.
6. *Krisna strigicollis* Spin., male: head, pronotum, and scutellum.
7. *Krisna muirii* sp. nov., head and pronotum.
8. *Krisna strigicollis* Spin., female; head and pronotum.

## PLATE II

FIG. 1. *Krisna colorata* sp. nov., head and pronotum; head slightly separated from pronotum in this specimen.
2. *Krisna simillima* sp. nov., head and pronotum.
3. *Krisna magna* sp. nov., female; head and pronotum.
4. *Krisna penangensis* sp. nov., head and pronotum.
5. *Krisna magna* sp. nov., male: head and pronotum; head slightly separated from pronotum in this specimen.
6. *Krisna olivascens* sp. nov., head and pronotum.
7. *Krisna strigicollis* Spin., lateral view of male genitalia.
8. *Krisna minima* sp. nov., male genitalia.
9. *Krisna strigicollis* Spin., male genitalia.
10. *Krisna nigrifrons* sp. nov., male genitalia.

## PLATE III

FIG. 1. *Krisna magna* sp. nov., male; face.
2. *Krisna nigrifrons* sp. nov., face.
3. *Krisna minima* sp. nov., face.
4. *Krisna magna* sp. nov., female; face.
5. *Krisna olivascens* sp. nov., face.
6. *Krisna minima* sp. nov., head and pronotum, side view.
7. *Krisna colorata* sp. nov., face.
8. *Krisna penangensis* sp. nov., face.
9. *Krisna olivascens* sp. nov., head and pronotum, side view.
10. *Krisna strigicollis* Spin., face.
11. *Krisna simillima* sp. nov., face.
12. *Krisna magna* sp. nov., male; head and pronotum, side view.
13. *Krisna muirii* sp. nov., face.
14. *Krisna magna* sp. nov., female; head and pronotum, side view.
15. *Krisna muirii* sp. nov., head and pronotum, side view.

## PLATE IV

FIG. 1. *Krisna colorata* sp. nov., female genitalia.
2. *Krisna muirii* sp. nov., head and pronotum, side view.
3. *Krisna magna* sp. nov., female genitalia.

4. *Krisna olivascens* sp. nov., female genitalia.
5. *Krisna penangensis* sp. nov., female genitalia.
6. *Krisna strigicollis* Spin., female genitalia.
7. *Krisna simillima* sp. nov., female genitalia.
8. *Krisna muirii* sp. nov., female genitalia.
9. *Krisna simillima* sp. nov., head and pronotum, side view.
10. *Krisna nigrifrons* sp. nov., head and pronotum, side view.
11. *Krisna penangensis* sp. nov., head and pronotum, side view.
12. *Krisna strigicollis* Spin., head and pronotum, side view.

PLATE V

FIG. 1. *Gessius malayensis* sp. nov., tegmen.
2. *Gessius malayensis* sp. nov., head and pronotum.
3. *Gessius pallidus* sp. nov., head and pronotum.
4. *Gessius pallidus* sp. nov., female genitalia.
5. *Gessius malayensis* sp. nov., female genitalia.
6. *Gessius pallidus* var. *suffusus* var. nov., head and pronotum, side view.
7. *Gessius malayensis* sp. nov., head and pronotum, side view.
8. *Gessius pallidus* var. *suffusus* var. nov., face.
9. *Gessius pallidus* sp. nov., head and pronotum, side view.
10. *Gessius malayensis* sp. nov., antenna.
11. *Gessius pallidus* var. *suffusus* var. nov., head and pronotum.
12. *Gessius malayensis* sp. nov., face.
13. *Gessius pallidus* sp. nov., face.

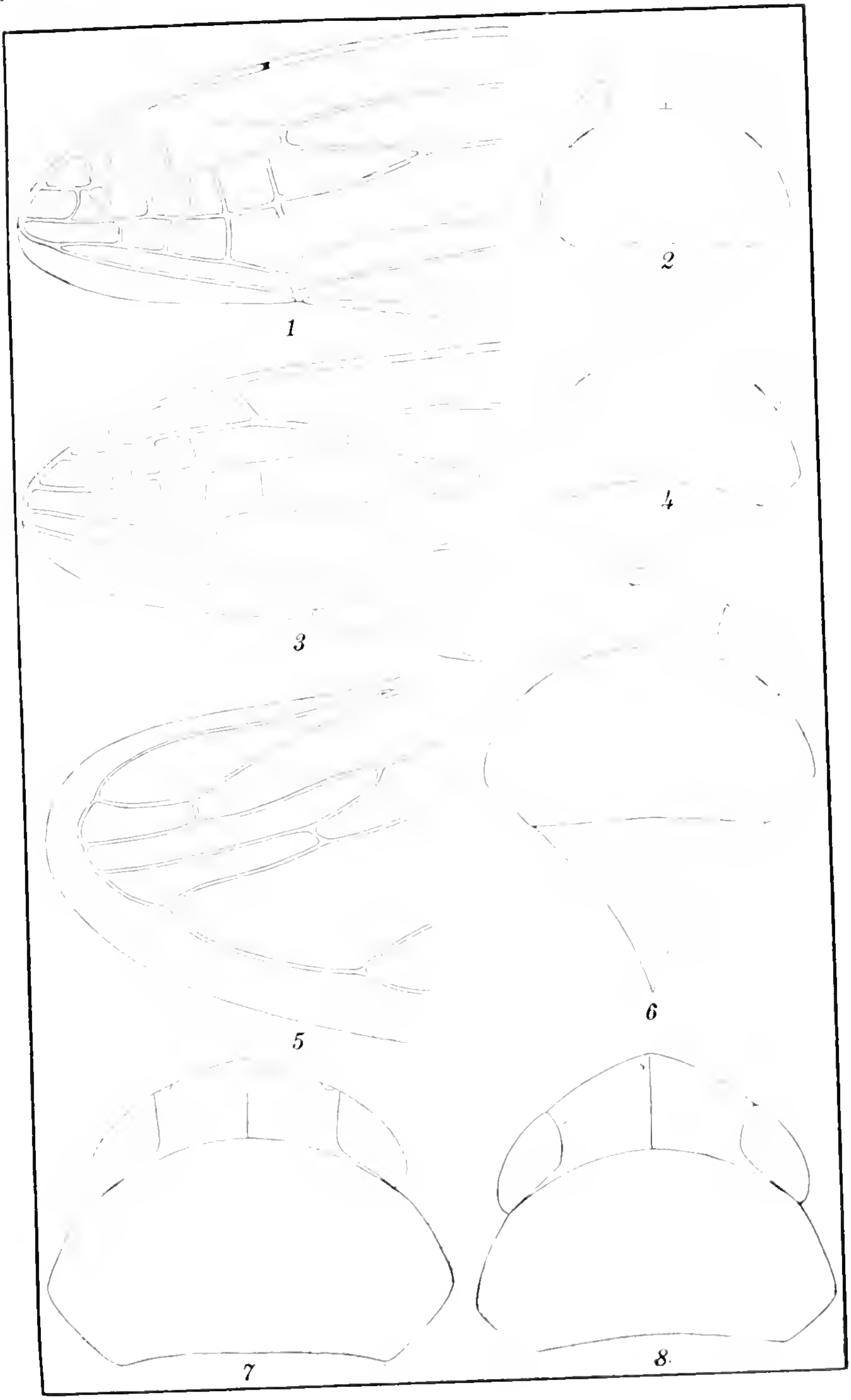



PLATE 1. SPECIES OF KRISNA.

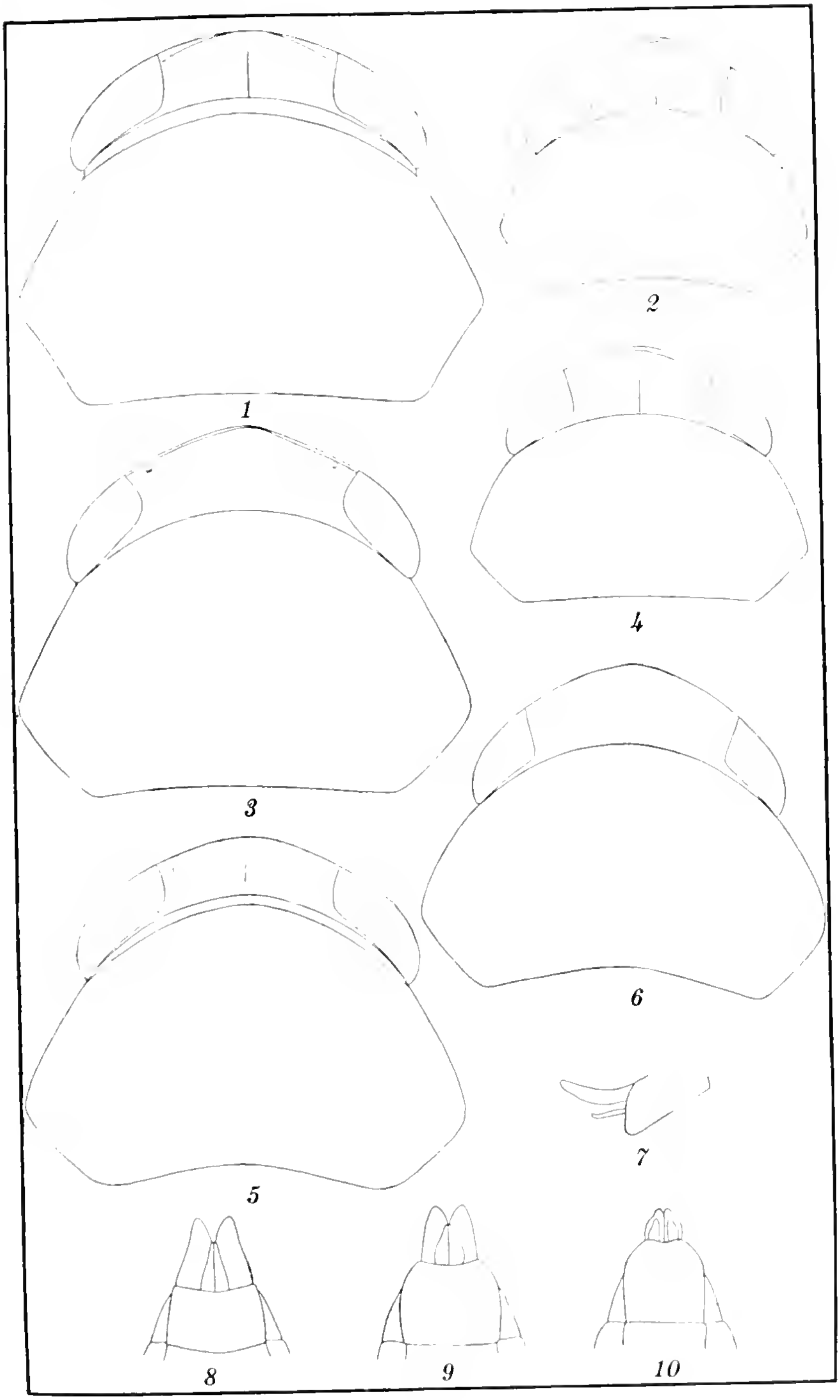



PLATE II. SPECIES OF KRISNA.

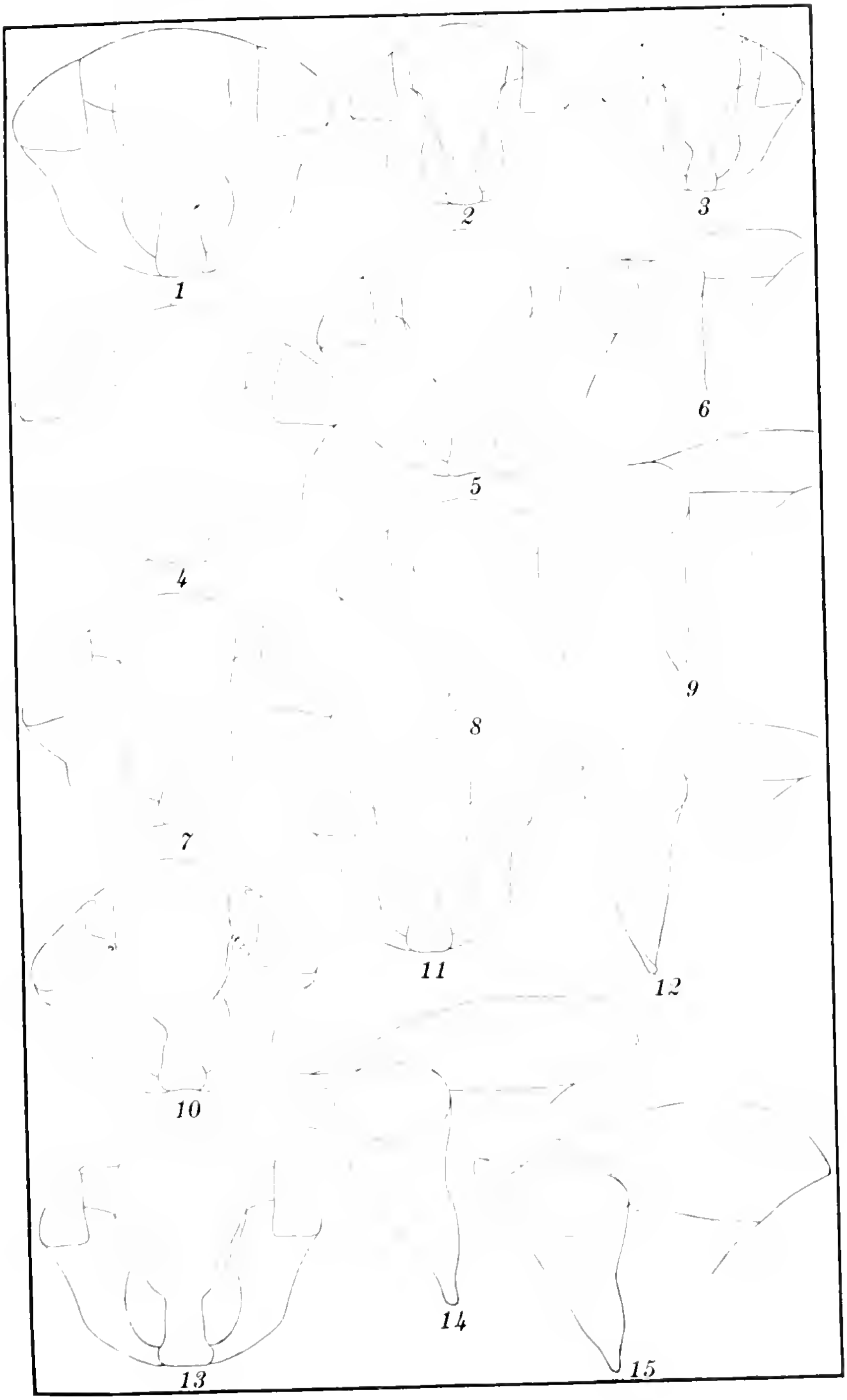



PLATE III. SPECIES OF KRISNA.

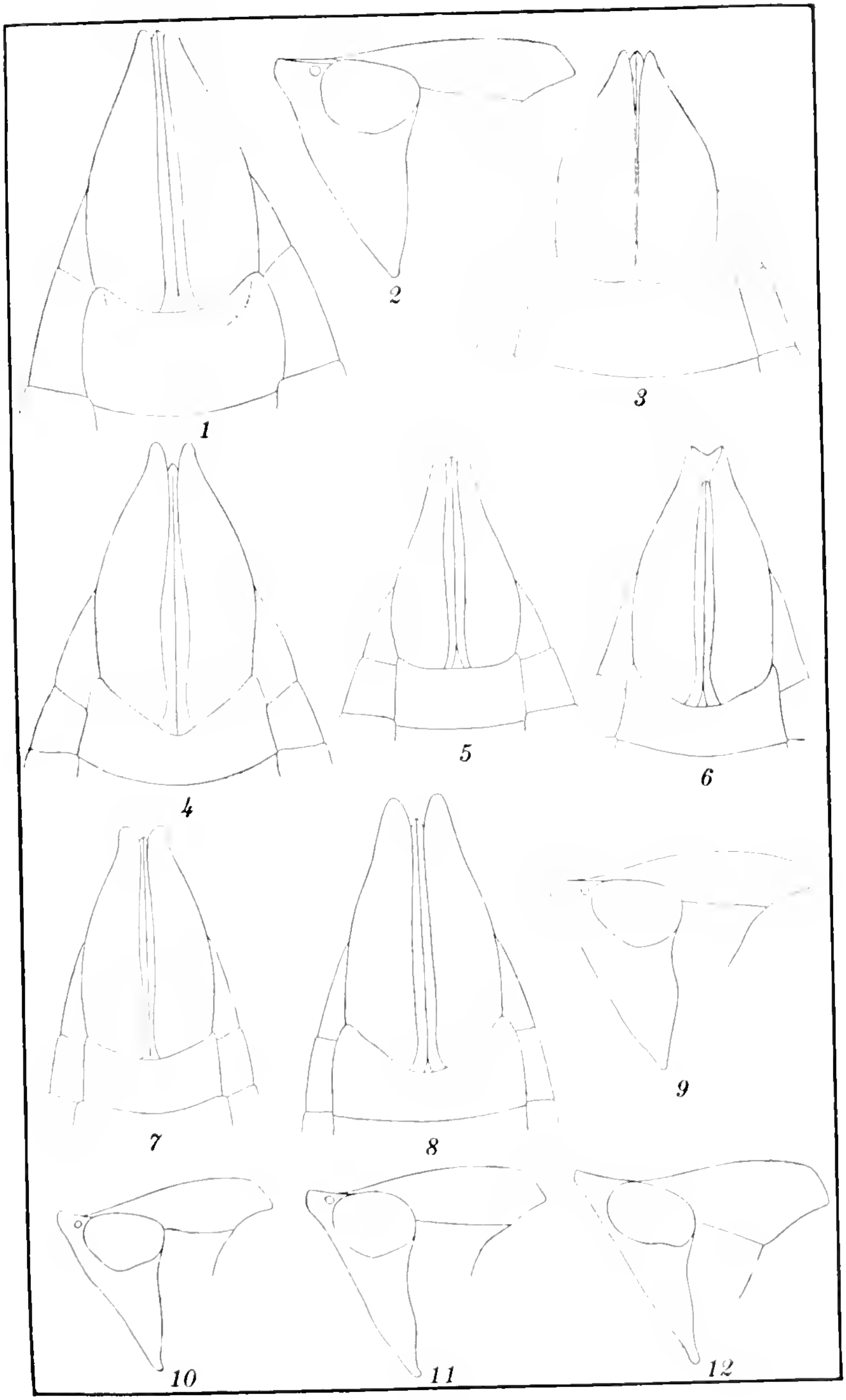



PLATE IV. SPECIES OF KRISNA.

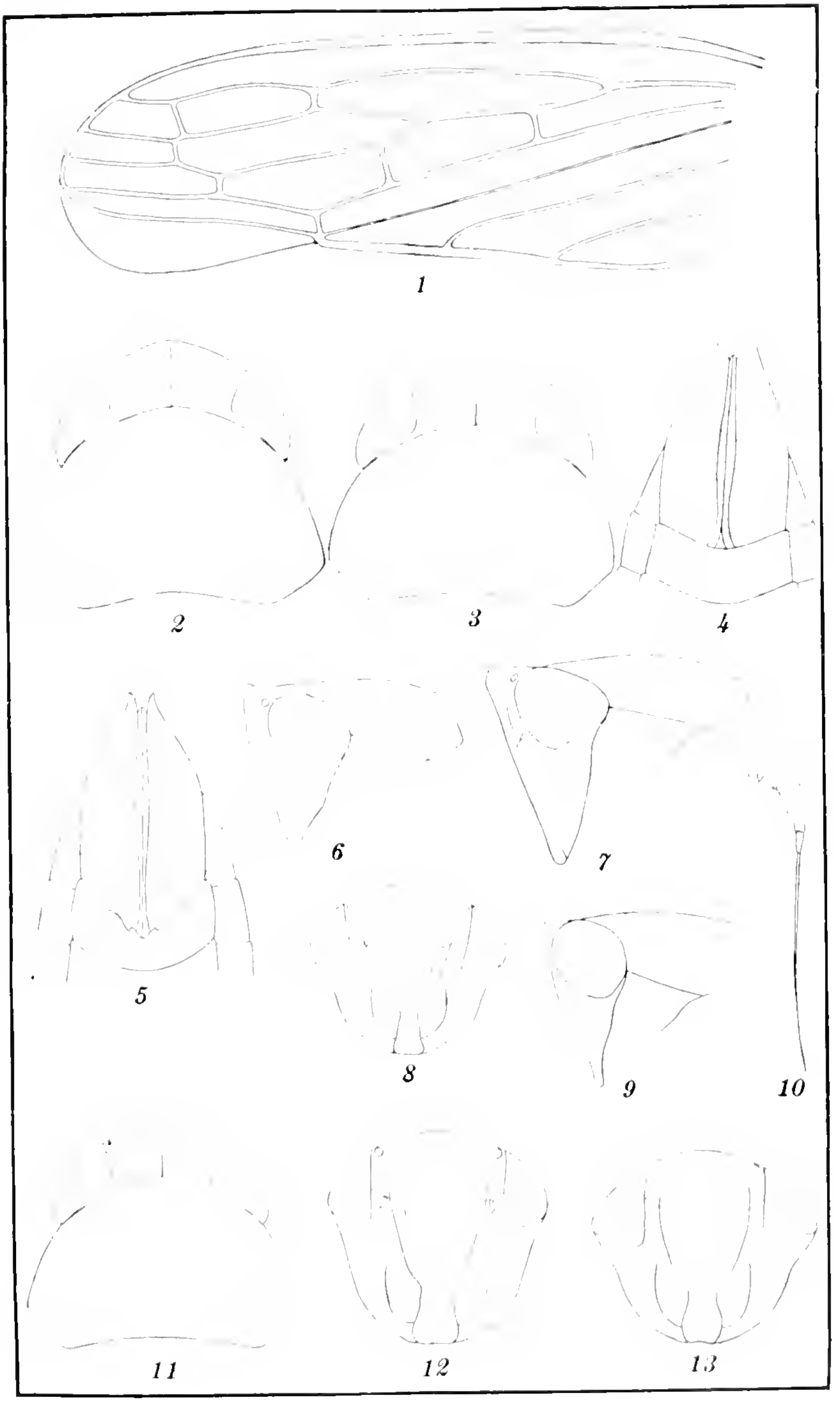



PLATE V. SPECIES OF GESSIUS.

THE PHILIPPINE

# JOURNAL OF SCIENCE

VOL. XV SEPTEMBER, 1919 No. 3

## THE PHYSICO-CHEMICAL VALORATION OF TIKITIKI EXTRACT[1]

By MARIANO V. DEL ROSARIO and JOAQUIN MARAÑON

*Of the University of the Philippines*

For a long time this country has been paying very dearly for exotic drugs. At present, however, there is the praiseworthy tendency to utilize our own resources in the preparation of the medicines used in combating the diseases peculiar to this part of the world.

The extract of tikitiki,[2] although recognized and prescribed for a number of years, has not usually been prepared according to any definite, standard method. Hence, differences in composition are found in the several brands that may be obtained in the market; that is, the products show different proportions as to their components. Consequently, we believe that our scientific authorities should adopt an official method for the preparation of this extract that would comply with established physical and chemical principles. The compound that we are considering as a standard is the one exemplified by the extract prepared by the Bureau of Science, Manila, according to the method of Chamberlain and Vedder,[3] which is the one used in this laboratory.

No definite conclusions leading to the formulation of a standard extract of this drug can be drawn from the results obtained in

[1] From the laboratory of pharmaceutical chemistry, School of Pharmacy, University of the Philippines.

[2] Tikitiki is the Philippine word meaning rice polishings.

[3] Chamberlain, Weston P., and Vedder, Edward B., The cure of infantile beriberi by the administration to the infant of an extract of rice polishings, and the bearing thereof on the etiology of beriberi, *Bull. Manila Med. Soc.* 4 (1912) 26.

our analytical work on the different brands of tikitiki extract as prepared in local drug stores and private laboratories. However, inspection of the results shows that extracts 1, 2, and 3 are of approximately equal concentration, while extracts 4 and 5 occur as much lower concentrations, this being shown by their specific gravity and the proportions of total solids they contain. The results of our analyses are summarized in Table I.

TABLE I.—*Results of analyses of samples of tikitiki extract.*

| | Bureau of Science, extract 1. | Extract 2. | Extract 3. | Extract 4. | Extract 5. |
|---|---|---|---|---|---|
| Temperature ..........°C.. | 28 to 25 | 26 to 25 | 30.3 to 30.1 | 28.5 to 30.1 | 29.3 to 29.6 |
| Specific gravity ............ | 1.2800 | 1.2960 | 1.2878 | 1.2254 | 0.9572 |
| Total solids......per cent.. | 53.23 | 56.20 | 50.33 | 25.53 | 5.40 |
| Reducing sugar (by direct reduction) ....per cent.. | 23.70 | 20.80 | 24.96 | 15.27 | 1.39 |
| Disaccharides (saccharose by inversion) .per cent.. | 2.56 | 0.30 | 0.65 | 0.57 | 0.17 |
| Mineral residue.... do..... | 4.40 | 3.32 | 4.87 | 0.76 | 0.19 |
| Total nitrogen by Kjeldahl .......... per cent.. | 2.008 | 2.300 | 1.640 | 0.856 | 0.140 |
| Phosphorus as $P_2O_5$.do..... | 1.70 | 0.375 | 2.14 | 0.24 | 0.165 |
| Sulphur (total) .....do..... | 0.26 | 0.109 | 1.11 | 0.059 | 0.001 |
| Amylolytic enzyme........ | negative | negative | negative | negative | negative |

A striking fact in this table is that extract 3, which has a higher specific gravity than extract 1, has however a lower percentage of total solids than that extract. This fact might be accounted for by the different methods used in removing the alcohol from the extract and by the extent of its dilution with water so as to obtain it at the desired concentration. Furthermore, we have the anomalous condition shown in extract 5, in which a sample with 5.4 per cent of total solids shows, at 29.3° to 29.6° C., a specific gravity of 0.9572. This condition might be explained by the presence of an unremoved residuum of the alcohol that was used as a solvent.

The determination of total solids in vacuum is undoubtedly the most accurate method for collecting such data; but, regrettably, our electric pump was not in working order at the time we undertook this investigation and we were forced, therefore, to employ other methods to obtain our results.

The amounts of reducing sugar and disaccharides are practically proportional to the total solids. The proportion between them, however, is variable and depends upon the degree of their hydrolyzation. In extract 2, which was purposely hydrolyzed, the proportion of disaccharides is very small.

It is very remarkable that in the majority of the samples the proportion of nitrogen is higher than that of phosphorus. Extracts 3 and 5, however, show the reverse condition. The amount of phosphorus in extract 3 is one and one-fourth as great as the nitrogen found in the same sample, and compared with the phosphorus of extract 2 it is six times as high, while the standard sample of the Bureau of Science is one-fourth lower in phosphorus than extract 3.

We have obtained uniformly negative results in our attempts to demonstrate the amylolytic enzyme. We assume that the reason for this is that the treatment of the extract with alcohol renders the enzyme inactive.

The figures we have obtained must be considered as being merely approximate, for it is quite apparent that analyses of the different samples of the same manufacturer, prepared at different times, will of necessity yield results that will vary to some extent. This is not surprising in view of the lack of a standard method for the preparation of this drug, to which we already have called attention. In fact, even though the same general procedure were followed, any qualitative variation in the raw material used, the concentration of the alcoholic solvent, the time during which the solvent and drug are in contact, the temperature at which extraction takes place, and the time over which evaporation is allowed to proceed when the vacuum is not employed—all these are factors that must be taken into account in the determination of the percentage composition of the extract.

The above discussion regarding tikitiki extract has been advanced from the viewpoint of the chemist; but it should be well borne in mind that systematic clinical studies by the physician must be carried out and carefully interpreted before determination can be made of the most desirable composition and the ultimate standardization of this drug, now so generally administered in the treatment of endemic neuritis.

# ADDITIONAL NOTES ON THE KWANGTUNG FLORA

By E. D. MERRILL

*Botanist, Bureau of Science, Manila*

This third paper on the flora of Kwangtung Province, China, is essentially like its predecessors.[1] In it have been included the descriptions of fifteen presumably new species, and records of thirty-four previously described forms either new to China or new to Kwangtung Province. The material on which these data are based has been collected by Mr. C. O. Levine and Mr. G. W. Groff, of the Canton Christian College, ably assisted by their Chinese collector To Kang P'eng.

In this paper have also been included some necessary changes in nomenclature for Chinese species occasioned by a recent preliminary study of Loureiro's Flora Cochinchinensis. This work was published in 1790. It contains the descriptions of one thousand two hundred ninety-four species and a few varieties, of which about six hundred thirty were described as new, the others ascribed to binomials established by Linnaeus. A preliminary examination of Loureiro's work shows that he frequently described some species twice, or sometimes even three or four times, under the same or under different generic names. In nearly one hundred cases reductions have been made, so that the total number of distinct species described by Loureiro is probably less than one thousand two hundred. In his interpretation of Linnean species he made numerous and frequently grave errors, and in about three hundred seventy cases, or about 56 per cent, he was wrong in the interpretation of such species. Loureiro described as new a total of one hundred eighty-five genera of which forty-two are generally adopted as valid ones or, if strict priority be followed, eliminating those names excluded by the lists of *nomina conservanda* adopted by the Vienna and the Brussels Botanical Congresses, fifty should be adopted. Fourteen of Loureiro's new genera have never been satisfactorily reduced and remain as doubtful ones.

[1] Merrill, E. D., Notes on the flora of Kwangtung Province, China, *Philip. Journ. Sci.* 12 (1917) Bot. 99–111; Notes on the flora of Loh Fau Mountain, Kwangtung Province, China, op. cit. 13 (1918) Bot. 123–161.

The title "Flora Cochinchinensis" is somewhat misleading, although more species were described from Cochin China than from any other single region. The geographic sources of his material are as follows: From Cochin China alone, about 697; from China alone, about 251; from both Cochin China and China, about 292; from tropical East Africa opposite Zanzibar, 29; from Mozambique, 9; from Zanzibar, 8; from India, 5; with 1 each from the Philippines, Sumatra, and the Malay Peninsula. Most of the Chinese material mentioned by Loureiro was from the immediate vicinity of Canton, where he resided for a period of three or four years.

In 1774 Loureiro mentions having sent about sixty specimens with descriptions to Europe, and in 1779 another lot of two hundred thirty specimens. I have not as yet succeeded in locating the first lot; the second shipment apparently consisted of those preserved in the herbarium of the British Museum. In the herbarium of the Paris Museum of Natural History ninety specimens from Loureiro are preserved, these having been secured by Geoffroy Saint-Hilaire in Lisbon in 1808. The bulk of Loureiro's collection, however, was retained by him in Lisbon and has long since been destroyed.[2]

Of the one thousand two hundred ninety-four species recognized by Loureiro not more than three hundred eighty are represented by known extant botanical material from his collections. In the much more numerous cases where Loureiro's types are no longer extant, the species must be interpreted from the original descriptions and such other data as can be secured for the regions in which the specimens were collected.

Considerable time was devoted to a preliminary study of Loureiro's species, and a manuscript commentary on the Flora Cochinchinensis was prepared by me and completed April 15, 1919. In this commentary Loureiro's species, so far as possible, were reduced to a family arrangement following the Engler and Prantl system. An attempt was made to determine the oldest valid specific name for each species and the necessary synonymy was added to explain the acceptance of the specific name in each case; all local names cited by Loureiro were recorded; and a more or less critical discussion of each species was given, together with the place of origin for each as cited by Loureiro. This manuscript was prepared in six copies, one of which is

[2] De Candolle, A, La Phytographie (1880) 430.

retained in Manila; one was sent to Dr. A. Chevalier, director of the Institut Scientifique in Saigon, Indo-China; one to the Canton Christian College, Canton, China; one to the library of the United States Department of Agriculture, Washington; one to the British Museum (Natural History), London; and one to the Muséum d'Histoire Naturelle, Paris. The essential object in preparing this manuscript was to establish a basis for further investigations regarding the status of Loureiro's species, as there still remains a high percentage of forms that are unintelligible from the descriptions alone. Eventually, when we shall have secured sufficient additional data to warrant doing so, it is hoped that a critical revision of Loureiro's species may be prepared and published.

The manuscript mentioned above summarizes in convenient form all the data at present available regarding the status of Loureiro's species in relation to those described by other authors, and from it can be determined those that are definitely known and those that are of a more or less doubtful status. Fourteen genera have not definitely been placed, of which twelve have not been referred to their proper families, while about three hundred seventy-five species are still more or less doubtful, and cannot, from the description alone, be safely correlated with those of other authors. Of these doubtful species many cannot be referred to their proper genera, and nearly fifty cannot be even referred to their proper families. Any great reduction in this rather high percentage of doubtful species cannot be expected until intensive field work shall have been prosecuted, with special reference to the problem, in southern China but more especially in Cochin China, in the vicinity of Hue where Loureiro resided.

## GRAMINEAE

### AGROPYRON Gaertner

AGROPYRON CILIARE (Trin.) Franchet in Nuov. Arch. Mus. Paris II 7 (1884) 151.

*Triticum ciliare* Trin. in Bunge Enum. Pl. Chin. Bor. (1831) 72.

Kwangtung Province, Shiuchow region, *To Kang P'eng 2827*, April, 1919.

A species of wide distribution in northern and central China but no representative of the genus hitherto recorded from as far south as Kwangtung.

## ARACEAE

### POTHOS Linnaeus

**POTHOS REPENS** (Lour.) comb. nov.

*Flagellaria repens* Lour. Fl. Cochinch. (1790) 212, ed. Willd. (1793) 263.

*Pothos loureirii* Hook. & Arn. Bot. Beechy's Voy. (1841) 220; Schott Aroid. 1 (1853) 23, *t. 49*, Prodr. (1860) 567; Engl. in DC. Monog. Phan. 2 (1879) 87; N. E. Br. in Journ. Linn. Soc. Bot. 36 (1903) 186, Curtis's Bot. Mag. *t. 7744;* Engl. Pflanzenreich 21 (1905) 35, *f. 15.*

*Pothos terminalis* Hance in Ann. Sci. Nat. V 5 (1866) 247.

*Pothos microphyllus* Schott Aroid. 1 (1853) 23, *t. 40, f. B.*

This species is known from Kwangtung Province, Hainan, and Tonkin, and is represented by *Levine 1989* from Teng Woo Mountain, Kwangtung Province, and by *Hongkong Botanic Garden 2243* from Hainan. The oldest valid specific name is here adopted, as Loureiro's description applies in all respects to the species as currently interpreted.

### ARISAEMA Martius

**ARISAEMA KWANGTUNGENSE** sp. nov. § *Pedatisecta.*

Herba circiter 40 cm alta; foliis solitariis, pedatisectis, segmentis plerumque 11, omnibus sessilibus, lanceolatis, acuminatis, 6 ad 9 cm longis, 1 ad 1.8 cm latis, basi angustatis; scapus 15 ad 18 cm longus; spathae tubus 5 cm longus, cylindricus, deorsum leviter angustatus; lamina ovata ad oblongo-ovata, 4 ad 5.5 cm longa, usque ad 3 cm lata, tenuiter acuminata, basi rotundata; spadicis appendix usque ad 10 cm longa.

Corms unknown. Peduncular part of the plant 15 to 20 cm long, bearing one leaf and one inflorescence, the free petiolar part of the leaf 4 to 6 cm long. Leaves pedately lobed, the segments mostly 11, membranaceous, lanceolate, slenderly acuminate, narrowed below, all sessile, 6 to 9 cm long, 1 to 1.8 cm wide. Scape 15 to 18 cm long, smooth, slender. Spathe pale green, its tube cylindric, slightly narrowed below, 5 cm long, the lamina membranaceous, ovate to oblong-ovate, 4 to 5.5 cm long, up to 3 cm wide, base rounded, apex slenderly acuminate but not caudate. Spadices unisexual, the staminate ones about 3 mm in diameter, floriferous for a distance of about 3 cm, the appendage slender, smooth, up to 10 cm long, 1 to 1.3 mm in diameter.

Kwangtung Province, Shiuchow region, *Levine 3565*, May 3, 1919, scattered along roads northeast of Nam Wa monastery.

I am unable to refer this specimen to any previously described species. It is apparently allied to *Arisaema japonicum* Blume.

## LILIACEAE

### SCILLA Linnaeus

**SCILLA SINENSIS** (Lour.) comb. nov.

*Ornithogallum sinense* Lour. Fl. Cochinch. (1790) 206.
*Barnardia scilloides* Lindl. in Bot. Reg. *t. 1029.*
*Scilla chinensis* Benth. Fl. Hongk. (1861) 373.

Loureiro's species is manifestly identical with the one currently known as *Scilla chinensis* Benth., the latter having been published independently of *Convallaria chinensis* Osbeck [3] which is unquestionably a synonym although very imperfectly described. It is not uncommon in open grassy places in the vicinity of Canton whence Loureiro secured his material, and is represented by the following Kwangtung material: *Merrill 10048*, *Levine 3270*, *3421*, the latter with the recorded local name *shik sun tau.*

### DISPORUM Salisbury

**DISPORUM CANTONIENSE** (Lour.) comb. nov.

*Fritillaria cantoniensis* Lour. Fl. Cochinch. (1790) 206.
*Disporum pullum* Salisb. in Trans. Hort. Soc. 1 (1812) 331.
*Uvularia chinensis* Ker in Curtis's Bot. Mag. *t. 916.*

Loureiro's material was from plants cultivated in Canton, for which he cites the local name *lin ni hoa.* Wright [4] admits *Fritillaria cantoniensis* Lour. with the following comment: "A doubtful plant supposed by Gawler to be the same as *Uvularia chinensis*, which is now reduced to *Disporum pullum* Salisb." Hooker f.,[5] under *Disporum pullum* Salisb. states: "The type of this species is the Chinese *Uvularia chinensis* of the Botanical Magazine, a purple flowered plant hardly distinguishable from shortly spurred specimens of *calcaratum.*" Loureiro's description is ample and applies unmistakably to *Disporum;* his specific name should be retained for the Chinese form currently referred to *Disporum pullum* Salisb. I am by no means certain that all the Indo-Malayan material currently referred to *Disporum pullum* Salisb. is conspecific with the Chinese form.

[3] Dagbok Ostind. Resa (1757) 220.
[4] Journ. Linn. Soc. Bot. 26 (1903) 136.
[5] Fl. Brit. Ind. 6 (1892) 260.

ASPARAGUS Tournefort

ASPARAGUS COCHINCHINENSIS (Lour.) comb. nov.

*Melanthium cochinchinense* Lour. Fl. Cochinch. (1790) 216.
*Asparagus lucidus* Lindl. in Bot. Reg. (1844) Misc. 29.

Loureiro observed this species in both China and Cochin China, and his description applies unmistakably to the well-known *Asparagus lucidus* Lindl., in spite of his description of the fruit as a capsule, this being a manifest error on the part of Loureiro. Kwangtung material representing the species, and for which the Cantonese name *tin tung* is recorded, corresponding to the form Loureiro cites, *tien muen tum*, is as follows: *Merrill 10699, Levine 2174, Groff 2290, Dunn 6337.* I have also examined the following specimens: Hongkong, *Curran.* Hainan, *Miss Moninger 62.* Formosa, *Faurie 947, Bot. Inst. Tokyo 1570.*

## ZINGIBERACEAE

PHRYNIUM Willdenow

PHRYNIUM PLACENTARIUM (Lour.) comb. nov.

*Phyllodes placentaria* Lour. Fl. Cochinch. (1790) 13.
*Phrynium parviflorum* Roxb. Fl. Ind. 1 (1820) 7; K. Schum. in Engl. Pflanzenreich 11 (1902) 54.

Loureiro observed this species both in China and in Cochin China. The generic name *Phyllodes* antedates *Phrynium,* but the latter is retained in the list of *nomina conservanda* adopted by the Vienna Botanical Congress. K. Schumann cites Loureiro's species as a doubtful synonym of *Phrynium capitatum* Willd., a purple-flowered species recorded from both China and Cochin China. From Loureiro's description of the flowers of his species as white I am convinced that he had specimens of the species currently known as *Phrynium parviflorum* Roxb., of which I have excellent specimens from Cochin China, *Pierre 626,* and from Kwangtung Province, China, *Levine 1873, Groff 2524,* with the recorded Cantonese name *chung ip,* corresponding to Loureiro's recorded Cantonese name *toung iep.*

## ORCHIDACEAE

SPIRANTHES L. C. Richard

SPIRANTHES ARISTOTELIA (Raeusch.) comb. nov.

*Epidendrum aristotelia* Raeusch. Nomencl. ed. 3 (1797) 265.
*Aristotelia spiralis* Lour. Fl. Cochinch. (1790) 522.
*Spiranthes australis* Lindl. in Bot. Reg. (1824) sub *t. 823,* non Koch.
*Neottia sinensis* Pers. Syn. 2 (1807) 511.
*Spiranthes sinensis* Ames Orch. 2 (1908) 53.

*Aristotelia spiralis* Lour., described by him as a new genus and species, was based on specimens from the vicinity of Canton.

It is represented by the following Kwangtung material, *Levine 1014, 2036, 2072,* growing in open grasslands, flowering in April and May. The species is one of very wide distribution, extending from India to Japan southward to New Zealand. Loureiro's type is preserved in the herbarium of the Paris Museum of Natural History.

## MORACEAE

### ANTIARIS Leschenault

ANTIARIS TOXICARIA (Pers.) Lesch. in Ann. Mus. Paris 17 (1810) 478.
*Ipo toxicaria* Pers. Syn. 2 (1807) 566.

Kwangtung Province, Kochow region, *To Kang P'eng 2755,* at Koon Shan temple, west of Kochow city, with the local name *to yiuk.*

Widely distributed in the Indo-Malayan region, but no representative of the genus previously recorded from China. This is the "deadly upas tree," its milky juice being widely used in the Indo-Malayan region for the purpose of poisoning spears and arrows.

### CUDRANIA Trécul

CUDRANIA PUBESCENS Tréc. in Ann. Sci. Nat. Bot. III 8 (1847) 125.

Kwangtung Province, Shiuchow region, Tan Ha Shan, *To Kang P'eng 2847,* April 25, 1919.

Yunnan Province, China, Burma, Java; new to Kwangtung.

### FICUS Linnaeus

FICUS VARIEGATA Blume Bijdr. (1825) 459; King in Ann. Bot. Gard. Calcutta 1 (1888) 169, *t. 212.*

Kwangtung Province, Kochow region, Ngau Tsai Wan, *To Kang P'eng 2743,* February 25, 1919, with the local name *tong kwo muk.*

This is the typical form of Blume's species, with broad, undulate-toothed leaves and large fruits. It is certainly specifically distinct from *Ficus chlorocarpa* Benth. which King referred to Blume's species as a variety. *Ficus chlorocarpa* Benth. is represented by *Merrill 10262* and *Levine 1889* from Kwangtung Province.

FICUS BENJAMINA Linn. Mant. 1 (1767) 129; King in Ann. Bot. Gard. Calcutta 1 (1887) 43, *t. 52.*

Kwangtung Province, Kochow region, Tai Shek Ling, *To Kang P'eng 2663,* March 18, 1919, with the local name *sai ip yung.*

Wild in various parts of the Malayan region and the Philip-

pines, frequently planted in other parts of tropical Asia. Not before recorded from China proper, although known from Hainan.

## LORANTHACEAE

### LORANTHUS Linnaeus

LORANTHUS PENTANDRUS Linn. Mant. 1 (1767) 63; Blume Fl. Jav. Loranth. (1828) 33, *t. 10;* Hook. f. Fl. Brit. Ind. 5 (1886) 216.

Kwangtung Province, Sai Sha, Sz Ooi, *Groff 2403*, April 24, 1918.

This species has not previously been reported from China; the specimens agree closely with the descriptions and with our rather full series of Malayan specimens.

LORANTHUS PARASITICUS (Linn.) comb. nov.

*Scurrula parasitica* Linn. Sp. Pl. (1753) 110, excl. syn. Camell et Petiver.

*Loranthus scurrula* Linn. Sp. Pl. ed. 2 (1762) 472, non auct. plur.

*Loranthus estipitatus* Stapf. (p. p.) in Trans. Linn. Soc. Bot. 4 (1894) 221; Forbes & Hemsl. in Journ. Linn. Soc. Bot. 26 (1844) 105; Dunn & Tutcher Fl. Hongk. Kwangtung (1912) 229 (as to the Chinese plant).

Kwangtung Province, vicinity of Canton, *Merrill 9987, Levine 1277, 1866, 1948, Groff 2314.* Hongkong, *Hongkong Herbarium 1232.*

The history of this species is as follows: The original binomial, *Scurrula parasitica* Linn., was manifestly based on a specimen, indicated by Linnaeus as originating in China, and in all probability collected by Osbeck near Canton; to the species Linnaeus erroneously referred "*Viscum vitici innascens* Camell. luz. 3 n. 36. Pet. gaz. t. 23, f. 8." Camell's description was based on specimens from Naic, Cavite Province, Luzon, and is manifestly *Loranthus philippensis* Cham. & Schlecht., an endemic Philippine species. Petiver's figure was in all probability based on Camell's drawing or on specimens from him, and a copy of the figure kindly supplied by Mr. Oakes Ames shows that it also represents *Loranthus philippensis* Cham. & Schlecht. The Linnean description does not apply to *Loranthus philippensis* Cham. & Schlecht., but does apply word for word to the Chinese form currently referred to *Loranthus estipitatus* Stapf, which is the commonest species of *Loranthus* found in the vicinity of Canton, the region in which Osbeck botanized. It does not apply to *Loranthus scurrula* of modern authors. In the second edition of the Species Plantarum Linnaeus made *Scurrula parasitica* the

basis of a new binomial, *Loranthus scurrula* Linn., but the earlier specific name should be adopted.

Fragments of recently collected material, cited above, were sent to London and were critically compared by Doctor Stapf with the Linnean type and with the type of *Loranthus estipitatus* Stapf. He writes under date of May 31, 1918, that as a result of his comparison this Chinese form must be accepted as *Loranthus scurrula* Linn. [= *L. parasiticus* (Linn.) Merr.], but that it is distinct from *L. estipitatus* Stapf. *Loranthus chinensis* DC is closely allied, if not identical.

LORANTHUS LEVINEI sp. nov. § *Scurrula*.

Frutex parasiticus, ramis usque ad 60 cm longis, teretibus, glabris, minute lenticellatis, ramulis dense ferrugineo-puberulis; foliis oblongis, coriaceis, obtusis, basi obtusis ad rotundatis, usque ad 8 cm longis, supra glabris, nitidis, olivaceis, subtus densissime ferrugineo-puberulis vel tomentosis, nervis utrinque 4 ad 6, supra distinctis, subtus obscuris; floribus axillaribus, 4-meris, fasciculatis, circiter 2.5 cm longis, curvatis, densissime ferrugineo-tomentosis, pedunculis 1- ad 3-floris, 3 ad 4 mm longis.

A parasitic shrub, the branches up to 60 cm in length, terete, glabrous, dark colored when dry, with scattered minute lenticels, the branchlets densely ferruginous-puberulent. Leaves opposite, subopposite, and alternate, oblong, coriaceous, 6 to 8 cm long, 2 to 3.5 cm wide, obtuse, base obtuse to rounded, the upper surface glabrous, olivaceous, shining, the lower densely ferruginous-puberulent or tomentose; lateral nerves 4 to 6 on each side of the midrib, rather distinct on the upper surface, the reticulations very lax, on the lower surface obscure or even obsolete; petiole 4 to 10 mm long, densely ferruginous-puberulent. Flowers axillary, fascicled, 4-merous, curved, about 2.5 cm long, densely ferruginous-pubescent or tomentose, the peduncles 1- or 2-flowered, 3 to 4 mm long, when 2-flowered the pedicels about 1 mm in length. Calyx oblong-ovoid, about 3 mm long, truncate, densely ferruginous-tomentose, subtended by a small, ovate bract. Corolla in bud curved, about 2.2 cm long, in anthesis split down one side, externally densely ferruginous-tomentose, the tube about 1.6 cm long; lobes reflexed, about 6 mm long, somewhat spatulate. Anthers continuous with the filaments, about 2 mm long.

Kwangtung Province, Lin District, Lo Chi Chui, *Levine 3321*, October 14, 1918, on trees along the river.

This species belongs in the group with *Loranthus parasiticus* Merr. and is perhaps most closely allied to *Loranthus yadoriki*

Siebold. It may be the Kwangtung species recorded by Dunn & Tutcher as *Loranthus scurrula* Linn., but is certainly not the Linnean species.

ELYTRANTHE Blume

ELYTRANTHE FORDII (Hance) comb. nov.

*Loranthus fordii* Hance in Journ. Bot. 23 (1885) 38.

This species is apparently common in Kwangtung Province and is clearly an *Elytranthe*. It is represented by the following specimens: White Cloud hills, *Levine 2076;* Ting Woo Monastery, *Levine 2035;* Honam Island, *Levine 1006,* and North River, Tseng Uen, *Levine 2390.* The specimens have the following local names: *shui chi kei shaang, koh muk kei shang,* and *wo ko.*

VISCUM Linnaeus

VISCUM STIPITATUM Lecomte in Sargent Pl. Wils. 3 (1916) 319.

Kwangtung Province, Lin District, Leung Kong Ngon, *Levine 3465,* October 28, 1918.

Lecomte's species was based on material from Yunnan Province, and Levine's excellent specimen exactly matches the description. In leaf characters the species is distinctly similar to *Ginalloa.*

VISCUM ANGULATUM Heyne ex DC. Prodr. 4 (1830) 225; Hook. f. Fl. Brit. Ind. 5 (1886) 225.

Kwangtung Province, Poon Yue District, *Levine 3165,* November, 1918, with the local name *kei shang.*

This species has not previously been recorded from China. The specimen is in fruit but agrees closely with Indian material representing Heyne's species. India to Australia.

## RANUNCULACEAE

RANUNCULUS Linnaeus

RANUNCULUS DIFFUSUS DC. Prodr. 1 (1824) 38.

Kwangtung Province, Shiuchow region, Tan Ha Shan, *To Kang P'eng 2901,* April, 1919, in grassy places.

India to China, Java, and Sumatra; not previously recorded from Kwangtung Province.

## BERBERIDACEAE

NANDINA Thunberg

NANDINA DOMESTICA Thunb. Fl. Jap. (1784) 9.

Kwangtung Province, Shiuchow region, Fan Kwai No Shan, *To Kang P'eng 2778,* April 19, 1919, in forests.

Widely distributed in Japan and China, but not previously found so far south as Kwangtung Province.

## MENISPERMACEAE

### DIPLOCLISIA Miers

**DIPLOCLISIA CHINENSIS** sp. nov.

Frutex scandens, glaber; foliis late ovatis ad subreniformibus, 5 ad 10 cm longis, 7 ad 12 cm latis, apice acutis, basi 5-nerviis, late truncato-rotundatis ad leviter cordatis, petiolo 4 ad 7 cm longo; inflorescentiis axillaribus, pedunculatis, umbellato-cymosis, 1.5 ad 3 cm longis; floribus ♂ 6-meris, sepalis ellipticis ad obovatis, circiter 2.5 mm longis, lineolatis, petalis rhomboideis 1.5 mm longis, apice rotundatis, basi cuneatis, auriculis lateralibus acutis, inflexis.

Scandent, glabrous, the branches and branchlets usually reddish brown, terete. Leaves chartaceous, olivaceous on both surfaces or somewhat glaucous beneath, broadly ovate to subreniform, 5 to 10 cm long, 7 to 12 cm wide, entire or the margin obscurely undulate, apex acute, base broadly truncate-rounded to shallowly cordate, 5-nerved; petioles 4 to 7 cm long. Inflorescences axillary, solitary, umbellate-cymose, the peduncles 1 to 2 cm long, the flower-bearing portion less than 1 cm in diameter, the pedicels 2 to 4 mm long, lineolate. Petals 6, rhomboid, 1.5 mm long, apex rounded, base acute, the auricles lateral, acute, inflexed; filaments 2 mm long.

Kwangtung Province, Shiuchow region, Fan Kwai No Shan, *To Kang P'eng 2764* (type), *2779 p. p.*, April 19, 1919.

This species is closely allied to *Diploclisia affinis* (Oliv.) Diels but differs in its larger leaves which are broadly ovate to subreniform, their bases truncate-rounded to shallowly cordate and not at all peltate. My specimen of *No. 2779* cited above consists in part of this species and in part of *Pericampylus glaucus* (Lam.) Merr.

## LAURACEAE

### LITSEA Lamarck

**LITSEA CUBEBA** (Lour.) Pers. Syn. 2 (1807) 4.

*Laurus cubeba* Lour. Fl. Cochinch. (1790) 252.

*Litsea piperita* Juss. in Ann. Mus. Paris 6 (1805) 213.

*Persea cubeba* Spreng. Syst. 2 (1825) 269.

*Daphnidium cubeba* Nees Syst. Lour. (1836) 615.

*Tetranthera cubeba* Meisn. in DC. Prodr. 15[1] (1864) 199.

*Litsea citrata* Blume Bijdr. (1825) 595; Lecomte Fl. Gén. Indo-Chine 5 (1914) 138; Gamble in Journ. As. Soc. Beng. 75[1] (1912) 146.

*Tetranthera citrata* Nees Syst. Lour. (1836) 560.

*Tetranthera polyantha* Wall. Cat. (1830) No. 2538, *nomen nudum*, Nees in Wall. Pl. As. Rar. 2 (1831) 67, Syst. Lour. (1836) 545.

*Tetranthera floribunda* Champ. in Hook. Kew Journ. Bot. 5 (1853) 199

Loureiro's material was from Cochin China, but his species and the numerous synonyms based upon it have never been satisfactorily placed and it is not mentioned by Lecomte in his recent treatment of the Lauraceae of Indo China.[6] Hemsley[7] states that he had seen only the fruit as it appears in commerce. It is evident from Loureiro's other descriptions of species of *Laurus* that the statement that the leaves of *Laurus cubeba* were nerveless was intended by him to imply that there were no longitudinal nerves as in *Cinnamomum*, for he placed all the species of *Cinnamomum* known to him under *Laurus*. The fruits are black, about the size, shape, and color of the fruits of black pepper, as Loureiro notes, and like the leaves are very aromatic. The species extends from Central China to India southward to Java, and it is manifest that Loureiro's specific name should be adopted for the species currently known as *Litsea citrata* Blume. I have examined the following material:

China, Kwangtung Province, *Merrill 10960*, *Levine & Groff 158*, *Levine 1398*, *3063*, *3248*, with the local name *tau shi keung*, *To Kang P'eng 2658*, with the local name *ts'ing tsz muk*: India, *Meebold 5532*, *Craib 255*: Indo China, *Bon 4278*: Malay Peninsula, Perak, *Scortechini 270b*, *Haniff & McNur 2323*: Java, *Koorders 3173*, *25602*, *27798*, *32911*, *38125*, *Winckel 256*.

## MACHILUS Nees

### MACHILUS LEVINEI sp. nov.

Arbor parva, glaberrima; foliis oblongis, crasse coriaceis, usque ad 18 cm longis, acuminatis, subtus glaucescentibus, nervis utrinque 15 ad 18, subtus distinctis; inflorescentiis terminalibus, ramis umbellato-fasciculatis, 2 ad 3.5 cm longis; perianthii segmentis anguste oblongis, coriaceis, glabris, circiter 10 mm longis.

A small, entirely glabrous tree, the branches and branchlets reddish brown, wrinkled when dry, not lenticellate. Leaves thickly coriaceous, oblong, 12 to 18 cm long, 3 to 4.5 cm wide, base obtuse to acute, apex shortly acuminate, the upper surface smooth, shining, rather pale when dry, the lower glaucous, the midrib impressed on the upper surface, very prominent and reddish brown on the lower; lateral nerves 15 to 18 on each side of the midrib, slender, distinct beneath, curved-ascending at an angle of about 45 degrees; petioles reddish brown, about 2.5 cm long. Inflorescences terminal, the primary branches about 8, reddish brown, umbellate-fascicled, 2 to 3.5 cm long, few-flowered. Perianth segments oblong or narrowly oblong, acute to obtuse,

[6] Fl. Gén. Indo-Chine 5 (1914) 107–158.
[7] Journ. Linn. Soc. Bot. 26 (1891) 380.

coriaceous, about 10 mm long and 3 mm wide, glabrous. Ovary glabrous. Immature fruit globose.

Kwangtung Province, Teng Woo Mountain, *Levine 2024*, May 26, 1918, scattered on slopes, altitude about 300 meters.

This species is well characterized by its oblong, thickly coriaceous, rather numerously nerved leaves which are glaucous beneath, and by its long, coriaceous, glabrous perianth segments. It is apparently as closely allied to *Machilus phoenicis* Dunn as to any other species, which, however, has smaller, differently shaped, fewer-nerved leaves and much shorter petioles.

### LINDERA Thunberg

**LINDERA SUBCAUDATA** (Merr.) comb. nov.

*Neolitsea subcaudata* Merr. in Philip. Journ. Sci. 13 (1918) Bot. 137.

Additional material with staminate flowers representing this species shows it to be a *Lindera*, allied to *L. strychnifolia* (Meisn.) F.-Vill. It is now represented by *Merrill 11016*, *Levine 1351*, *Groff 2463*, *To Kang P'eng 2707*, the latter with staminate flowers bearing the local name *heung kau shü*.

## SAXIFRAGACEAE

### ANDROSACE Linnaeus

**ANDROSACE UMBELLATA** (Lour.) comb. nov.

*Drosera umbellata* Lour. Fl. Cochinch. (1790) 186.

*Androsace saxifragifolia* Bunge in Mém. Acad. St. Pétersb. 2 (1836) 127; Pax & Knuth in Engl. Pflanzenreich 22 (1905) 179.

Loureiro cites both Chinese and Cochinchinese names for this species, although he also states "Habitat in China." It would seem that he observed the species in both regions. The species extends from India to Japan southward to Indo-China and northern Luzon and occurs at low altitudes both in Kwangtung Province, China, and in Indo China. The species is clearly no *Drosera*, but among all the species of plants known from southern China, Loureiro's description applies only to *Androsace saxifragifolia* Bunge. There is, hence, no reason why Loureiro's specific name should not be adopted for this well-known species. Planchon[a] has already indicated that Loureiro's species might be an *Androsace*.

## ROSACEAE

### PYGEUM Gaertner

**PYGEUM TOPENGII** sp. nov. § *Sericophyllum*.

Arbor circiter 12 m alta, ramis glabris, ramulis ferrugineo-pubescentibus; foliis coriaceis, elliptico-ovatis, usque ad 9 cm

[a] Ann. Sci. Nat. III 9 (1848) 304.

longis, breviter obtuse acuminatis, basi plerumque acutis, leviter inaequilateralibus, haud vel obscurissime glandulosis, supra in siccitate pallidis, nitidis, glabris, subtus ad costa nervisque leviter ciliatis, nervis utrinque 6 vel 7, subtus perspicuis; infructescentiis axillaribus, solitariis, depauperato-paniculatis, 4 ad 5 cm longis; fructibus subreniformibus, glabris, minute apiculatis, circiter 8 mm longis, 10 ad 12 mm latis; seminibus solitariis, testa extus sericeis.

A tree about 12 m high, the branches dark reddish brown, lenticellate, glabrous, the branchlets ferruginous-pubescent as are the petioles and apparently the inflorescences. Leaves coriaceous, elliptic-ovate, 6 to 9 cm long, 3 to 5 cm wide, shortly and rather bluntly acuminate, base acute, usually somewhat inequilateral, eglandular or the glands obscure and not at all projecting, the upper surface, except in very young leaves, glabrous, pale and shining when dry, the lower somewhat ciliate on the midrib and nerves; lateral nerves 6 or 7 on each side of the midrib, prominent; petioles 5 to 7 mm long; stipules oblong, pubescent, deciduous, about 5 mm long. Infructescences axillary, solitary, from the branchlets below the leaves, 4 to 5 cm long, sparingly pubescent, usually with a single basal branch 1 to 2 cm in length. Fruits subreniform, brown when dry, slightly apiculate, glabrous, about 8 mm long, 10 to 12 mm wide, their pedicels 3 mm long or less. Seeds solitary, the testa distinctly silky-villous.

Kwangtung Province, Kochow region, Shek Kau Tong, *To Kang P'eng 2750*, March 5, 1919.

*Pygeum henryi* Dunn is the only species of the genus definitely known from China, but the present one is entirely different. *Pygeum latifolium* Miq. is recorded from Hongkong by Hemsley but Miquel's species is definitely known only from Java, having long been confused with a Philippine species. It is possible that the present species is identical with the Chinese form previously referred to *Pygeum latifolium* Miq., but it is safely not Miquel's species.

### SANGUISORBA Ruppius

SANGUISORBA OFFICINALIS Linn. Sp. Pl. (1753) 116.

Kwangtung Province, Lin District, Shan Mo Ling and Sing Tize Foo, *Levine 3181, 3191*, September 15, 1918, with the local name *mar lin on*.

The genus is new to Kwangtung Province. There seems to be some difference of opinion among botanists as to the distribution of Chinese forms of this genus between *Sanguisŏrba offi-*

*cinalis* Linn. and *S. canadensis* Linn., the present material matching specimens from various parts of China, some identified as *S. officinalis* Linn. and some as *S. canadensis* Linn. The Kwangtung material closely matches European material of *S. officinalis* Linn., and I assume this name to be correct for it. *Sanguisorba formosana* Hayata, as represented by Formosan material, *Kawakami 93*, is scarcely to be distinguished.

### POTENTILLA Linnaeus

**POTENTILLA DISCOLOR** Bunge Enum. Pl. Chin. Bor. (1831) 25.

Kwangtung Province, Shiuchow region, *To Kang P'eng 2775*, April 19, 1919.

Widely distributed in northern and central China, extending to Formosa (a variety); not previously recorded from Kwangtung Province.

## LEGUMINOSAE

### PITHECOLOBIUM Martius

**PITHECOLOBIUM TURGIDUM** sp. nov.

Arbor parva, partibus junioribus ferrugineo-pubescentibus; foliis bipinnatis, pinnis 1-jugis, foliolis amplis, bijugis, membranaceis vel chartaceis, glabris, nitidis, acuminatis, majoribus usque ad 15 cm longis, oblongo-ovatis, basi acutis, nervis utrinque 6 ad 8, perspicuis; leguminis turgidis, rectis, dehiscentibus, oblongis, 7 ad 9 cm longis circiter 3 cm latis, et 1 ad 1.5 cm crassis, valvis coriaceis; seminibus ellipsoideis, 1.8 ad 2.5 cm longis, haud compressis.

A small tree, 3 to 4 m high *fide* Levine, glabrous except the younger parts which are ferruginous- or castaneous-pubescent. Leaves bipinnate, pinnae 1-jugate, leaflets bijugate, the petiole 2 to 6 cm long, with a single large gland at the apex below the insertion of the single pair of terminal pinnae, the rachises of the pinnae 5 to 8 cm long, each bearing four large leaflets and usually with a terminal gland; leaflets membranaceous to chartaceous, oblong-ovate to elliptic-ovate, pale greenish and shining when dry, glabrous, base acute, equilateral, the apex acuminate, 9 to 15 cm long, 4 to 7 cm wide, the lateral nerves 6 to 8 on each side of the midrib prominent. Panicles pyramidal, in bud up to 14 cm long, the flowers in globose heads at the tips of the branchlets, pubescent. Pods oblong, turgid, dehiscent, 7 to 9 cm long, about 3 cm wide, 1 to 1.5 cm thick, each usually with about four seeds, the sutures not thickened, the valves coriaceous, continuous, brown, smooth. Seeds contiguous, ellipsoid,

not compressed, brown, smooth, shining, 1.8 to 2.5 cm long, persistent for a considerable period after the pod dehisces by the elongated, slender, more or less curved funiculus, the latter about 1 cm in length.

Kwangtung Province, Teng Woo Mountain, *Levine & Groff 86*, November 18, 1916, with mature fruits, *Levine 1976*, April 26, 1918, from the same tree, with immature buds and fully mature seeds; along streams, altitude about 300 meters.

This species, distributed as an *Albizzia*, like its congener, *Pithecolobium balansae* Oliv., and apparently *P. attopeuense* Pierre (of which the fruits are unknown), is anomalous in *Pithecolobium* in its straight, turgid, not at all twisted or curved pods, and is equally anomalous in *Albizzia*. It is suspected that it may prove to represent a distinct generic type.

### PAHUDIA Miquel

PAHUDIA XYLOCARPA Kurz Forest Fl. Brit. Burma 1 (1877) 413.

Kwangtung Province, Kochow region, Sai Ngon, *To Kang P'eng 2705*, February 18, 1919, a single tree, said to have been grown from seeds secured in Burma. It is locally known as *min ke*.

The specimen, which presents a mature pod and seeds, agrees closely with Kurz's description, the species having been based on material originating near the Burmese border of Siam.

### CASSIA Linnaeus

CASSIA FISTULA Linn. Sp. Pl. (1753) 377.

Kwangtung Province, Tak Hing, *Levine 3587*, April, 1919, from an introduced and cultivated tree. A native of tropical Asia, pantropic in cultivation.

### ORMOSIA Jackson

ORMOSIA HAINANENSIS Gagnep. in Not. Syst. 3 (1914) 31.

Hainan, *Hongkong herbarium 443! Miss Moninger 122!*, in fruit: Kwangtung Province, Kochow region, Shek Kau T'ong, *To Kang P'eng 2664*, March 3, 1919, in forests.

The pods, description from Miss Moninger's Hainan specimen, contain from 1 to 4 seeds, and when more than 1-seeded are somewhat torulose. They are 2 to 4 cm long and 1 to 1.5 cm wide, much thickened, glabrous, brown when dry, the valves thickened, somewhat woody, irregularly twisted after dehiscence. Seeds red, dangling from the pod after dehiscence, not arillate, 15 to 18 mm long. When but 1-seeded the pods are usually con-

spicuously stipitate, but the pseudostalk presents several undeveloped ovules. The species seems to be allied to *Ormosia fordiana* Oliv.[9]

### PTEROLOBIUM R. Brown

PTEROLOBIUM ROSTHORNII Harms in Engl. Bot. Jahrb. 29 (1900) 410.

Kwangtung Province, Lin District, Pak hill, *Levine 3208*, October 21, 1918, with the local name *ye tau*.

This is the second species of the genus to be found in Kwangtung Province. The material agrees very closely with the original description, which, however, is rather short and imperfect. It has not otherwise been reported except by the original collections in southern Szechuen. The Kwangtung material is in fruit, the wings being 1.2 to 1.5 cm wide, brown and shining when dry, and apiculate-acuminate by the nearly straight upper suture which is slightly produced at the tip.

### DERRIS Loureiro

DERRIS ELEGANS (Grah.) Benth. in Miq. Pl. Jungh. (1852) 252, Journ. Linn. Soc. Bot. 4 (1860) Suppl. 109; Baker in Hook. f. Fl. Brit. Ind. 2 (1878) 252.

*Pongamia elegans* Grah. in Wall. Cat. (1832) No. 7540, *nomen nudum*.

Kwangtung Province, Shai Chiu Mountain, *Levine 2074*, May 4, 1918, with the local name *kau ngar fa*.

This species has not previously been reported from China, but the flowering specimen cited above is an excellent match for our large series of Philippine specimens representing it; fruiting specimens of the Chinese form are desirable to verify the correctness of the determination.

Tenasserim, Andaman Islands, Malay Peninsula, Sumatra, and the Philippines.

DERRIS TRIFOLIATA Lour. Fl. Cochinch. (1790) 433.

The genus *Derris* was based by Loureiro on two species. The first, *D. pinnata*, the type of which is preserved in the herbarium of the British Museum, is *Dalbergia pinnata* (Lour.) Prain, a species of wide distribution in the Indo-Malayan region more commonly known as *Dalbergia tamarindifolia* Roxb. The second species described by Loureiro, *D. trifoliata*, was based on specimens from the vicinity of Canton, and the type is preserved in the herbarium of the Paris Museum of Natural History. I am of the opinion that this species should be interpreted as the type of the genus *Derris*. The species by many authors has been reduced to *Derris uliginosa* (Roxb.) Benth., and a recent critical

[9] In Hook. Ic. IV 5 (1895) *t. 2422*.

examination of the type by Doctor Gagnepain shows that it is identical with Roxburgh's species. Prain[10] thought that Loureiro's description did not apply sufficiently closely to *Derris uliginosa* to warrant reducing Loureiro's species to the latter. The examination of the type by Doctor Gagnepain, however, definitely settles this matter; and Loureiro's name, being the older, should be retained for this very common, characteristic, and widely distributed species. It occurs typically along the margins of tidal streams more or less subject to the influence of brackish or salt water, from tropical East Africa through India to southern China and Formosa, southward through Malaya to tropical Australia and Polynesia.

DUNBARIA Wight and Arnott

DUNBARIA ROTUNDIFOLIA (Lour.) comb. nov.

*Indigofera rotundifolia* Lour. Fl. Cochinch. (1790) 458.
*Dolichos conspersus* Grah. in Wall. Cat. (1831–32) No. 3342, *nomen nudum.*
*Dunbaria conspersa* Benth. in Miq. Pl. Jungh. (1852) 242.
*Dunbaria punctata* Benth. l. c.
*Dolichos punctatus* Wight & Arn. Prodr. (1834) 237.

Loureiro's type was from the vicinity of Canton, and his description applies closely to the species currently known as *Dunbaria conspersa* Benth. except that the pods have more than two seeds. No other leguminous species known from Kwangtung agrees at all with Loureiro's description. I have examined the following Kwangtung specimens: *Merrill 10146, Levine 1111, 3345.* Loureiro records the Cantonese name as *o tam sin;* that recorded on one of Levine's specimens is *chin tang*, not very different from Loureiro's name if the words be reversed.

MUCUNA Adanson

MUCUNA COCHINCHINENSIS (Lour.) A. Chev. in Bull. Agr. Inst. Sci. Saigon 1 (1919) 91.

*Marcanthus cochinchinensis* Lour. Fl. Cochinch. (1790) 461.
*Carpopogon niveum* Roxb. Fl. Ind. ed. 2, 3 (1832) 385.
*Mucuna nivea* Wight & Arn. Prodr. (1834) 255.
*Stizolobium niveum* O. Kuntze Rev. Gen. Pl. (1891) 207.

Kwangtung Province, Lin District, *Levine 3283,* with the local name *kau chau tau t'ang.*

Loureiro's material was from Cochin China, undoubtedly from the vicinity of Hue where he resided most of the time while

[10] Journ. As. Soc. Beng. 66 [2] (1898) 458.

in Cochin China. His description applies unmistakably to the widely distributed and cultivated species currently known as *Mucuna nivea* Wight & Arn., and his specific name will replace that based on Roxburgh's binomial. Loureiro's description of the pods was apparently based on fresh rather than on dried material. Loureiro resided at Hue, and a mature pod secured from this locality under the local name cited by Loureiro, submitted to me by Dr. A. Chevalier, is identical with *Mucuna nivea* Wight & Arn. Prof. C. V. Piper informs me that he examined Loureiro's type in the herbarium of the British Museum in 1912, a leaf specimen only, making the note at that time that it might be any of the species allied to *Mucuna nivea*, but that it probably represented the latter species.

## POLYGALACEAE

### POLYGALA Linnaeus

POLYGALA TENUIFOLIA Willd. Sp. Pl. 3 (1800) 879.

Kwangtung Province, Shiuchow region, *To Kang P'eng 2809, 2770, 2903*, in thickets and forests.

In China previously recorded from Chihli, Shingking, and Shantung, but not previously reported from southern China. The specimens cited above agree closely with material from Chihli, differing chiefly in some of the leaves being broader than in the northern form.

## EUPHORBIACEAE

### EUPHORBIA Linnaeus

EUPHORBIA ESULA Linn. Sp. Pl. (1753) 461; Boiss. in DC. Prodr. $15^2$ (1862) 160; Forbes & Hemsl. in Journ. Linn. Soc. Bot. 26 (1894) 412.

Kwangtung Province, North River, Fu Ok, *Groff 2279*, March, 1918.

Widely distributed in Asia, but not previously reported from southern China.

### EXCOECARIA Linnaeus

EXCOECARIA COCHINCHINENSIS Lour. Fl. Cochinch. (1790) 612; Muell.-Arg. in DC. Prodr. $15^2$ (1866) 1215.

Kwangtung Province, cultivated at the Canton Christian College, *Groff 2963*. This is the typical form with red leaves, cultivated for ornamental purposes; namely, typical *Excoecaria bicolor* Hassk.

EXCOECARIA COCHINCHINENSIS Lour. Fl. Cochinch. (1790) 612, var. VIRIDIS (Pax & K. Hoffm.).

*Excoecaria bicolor* Hassk. Retzia 1 (1855) 158, var. *viridis* Pax & K. Hoffm. in Engl. Pflanzenreich 52 (1912) 159.

Kwangtung Province, Kochow region, Kwong T'am, *To Kang P'eng, 2672*, March 22, 1919.

I believe the cultivated form with colored leaves described by Loureiro as *Excoecaria cochinchinensis* to be identical with *Excoecaria bicolor* Hassk., which being the case Loureiro's name should be retained. The type of *Excoecaria bicolor* Hassk. var. *viridis* Pax & K. Hoffm. was from Cochin China, and the description agrees entirely with the specimen cited above. The species is new to China.

ALCHORNEA Swartz

ALCHORNEA RUGOSA (Lour.) Muell.-Arg. in Linnaea 34 (1865) 170.

*Alchornea hainanensis* Pax & K. Hoffm. in Engl. Pflanzenreich 63 (1914) 242 !

*Cladodes rugosa* Lour. Fl. Cochinch. (1790) 574.

Kwangtung Province, Kochow region, Kwanshan temple, *To Kang P'eng 2662*, March 18, 1919.

This is the first record of the species from China proper, although it had previously been recorded from Hainan Island. Unless *Alchornea rugosa* (Lour.) Muell.-Arg. is variable in the number of its stamens, it would seem that Pax and Hoffmann are wrong in their interpretation of *Alchornea rugosa*, and that they described as a new species the typical form as described by Loureiro under *Cladodes rugosa*. Loureiro describes his species as having eight stamens, the only character depended upon by Pax and Hoffmann in separating the Hainan form from *Alchornea rugosa*. In *Alchornea hainanensis* the staminate flowers have eight stamens, as does the Kwangtung specimen cited above, thus agreeing with Loureiro's original description of *Cladodes rugosa*. J. J. Smith states that in all staminate flowers of the Javan form referred by him to *Alchornea rugosa* the number of stamens was four; Pax and Hoffmann state stamens 4, rarely 5 or 6. The actual specimens so closely resemble each other that I strongly suspect that the species has a variable number of stamens, 4 to 8. Should this not prove to be the case, then Loureiro's specific name will have to be retained for the form characterized by Pax and Hoffmann as *Alchornea hainanensis*, while for the common Malayan form the name *Alchornea javanensis* (Blume) Muell.-Arg. will have

to be revived, or the still earlier one, *Croton apetalum* Blume, transferred to *Alchornea*. It is to be noted that Pax and Hoffmann saw no Cochin China material representing Loureiro's species.

## ANACARDIACEAE

### POUPARTIA Commerson

**POUPARTIA CHINENSIS** sp. nov.

Arbor circiter 8 m alta, inflorescentiis exceptis glabra; foliis 20 ad 30 cm longis, foliolis 11 ad 15, membranaceis ad chartaceis, oblongo-lanceolatis, 6 ad 9 cm longis, acuminatis, leviter inaequilateralibus, glabris vel junioribus subtus in axillis leviter barbatis, nervis utrinque 9 ad 12; petiolulis circiter 2 mm longis; inflorescentiis terminalis, amplis, circiter 30 cm longis, ramis inferioribus usque ad 15 cm longis, cinereo-pubescentibus; floribus ♂ 5-meris, calyces circiter 1.5 mm diametro; petalis oblongis, 2.5 mm longis, reflexis; staminibus 10, filamentis 2 ad 2.3 mm longis; ovario glabro, 4- ad 5-locellato.

A tree about 8 m high, the inflorescences more or less cinereous-pubescent. Ultimate branches about 5 mm in diameter, smooth, glabrous, terete. Leaves 20 to 30 cm long, the rachis sparingly pubescent; leaflets 11 to 15, membranaceous to chartaceous, oblong-lanceolate, 6 to 9 cm long, 1.5 to 2.5 cm wide, somewhat inequilateral at the base, apex acuminate, glabrous, or the younger ones sparingly bearded in the axils on the lower surface; lateral nerves 9 to 12 on each side of the midrib, slender; petiolules about 2 mm long. Inflorescence a terminal leafy panicle about 30 cm in length, the lower branches up to 15 cm long, subtended by normal but usually reduced leaves, the upper 15 to 20 cm of the panicle leafless; the branches, branchlets, and pedicels cinereous-pubescent. Flowers numerous, white, pistillate and staminate ones in the same inflorescences. Calyx of the staminate flowers about 1.5 mm in diameter, the lobes 5, ovate, acute or obtuse, about 0.5 mm long. Petals oblong, 2.5 mm long, their margins somewhat inflexed, reflexed in anthesis, nerveless. Stamens 10, their filaments filiform, 2 to 2.3 mm long. Pistillate flowers similar to the staminate ones. Ovary glabrous, 4- or 5-celled; styles 4 or 5, about 1 mm long.

Kwangtung Province, Honam Island, on the campus of Canton Christian College, *Levine 3521*, May 13, 1919.

This is the second species of the genus to be found in China, differing radically from *Poupartia fordii* Hemsl. in its very much larger, terminal, distinctly pubescent inflorescences, the

staminate and pistillate flowers borne in the same inflorescences; much smaller pistillate flowers; much more numerous leaflets; and shorter petiolules.

## CELASTRACEAE

### CELASTRUS Linnaeus

CELASTRUS HOOKERI Prain in Journ. As. Soc. Beng. 72[2] (1904) 197; Rehd. & Wils. in Sargent Pl. Wils. 2 (1915) 352.

Kwangtung Province, North River and Shiuchow regions, *Groff 300, 2294, To Kang P'eng 2875.*

India; previously recorded from China from Yunnan, Szech'uan, and Fokien, but not before reported from Kwangtung Province.

## SAPINDACEAE

### KOELREUTERIA Lakman

KOELREUTERIA BIPINNATA Franch. in Bull. Soc. Bot. France 33 (1886) 463, Pl. Delavay. (1889) 143, *t. 29, 30.*

Kwangtung Province, Ying Tak District, *Levine 3484*, December 9, 1918.

This species is new to Kwangtung Province and this record represents a considerable southward extension of range for it. The specimen is in fruit and agrees closely with our rather full series of specimens from Yunnan Province.

## ELAEOCARPACEAE

### ELAEOCARPUS Linnaeus

ELAEOCARPUS DUBIUS A. DC. in Bull. Herb. Boiss. II 2 (1903) 366; Gagnep. in Lecomte Fl. Gén. Indo-Chine 1 (1910) 572.

Kwangtung Province, Kochow region, Shek Kau Tong, *To Kang P'eng 2686*, March 5, 1919, in forests.

The specimen agrees in all respects with the descriptions of this species and with *Bon 4298!, 2671!* from Tonkin. Previously known only from Tonkin.

## MALVACEAE

### HIBISCUS Linnaeus

HIBISCUS SURATTENSIS Linn. Sp. Pl. (1753) 696.

Kwangtung Province, Kochow region, Fat Tsz Ling, *To Kang P'eng 2730*, February, 1919, along roadsides.

This widely distributed Indo-Malayan species has been recorded from Hainan, but I can find no record for it from China proper.

## THEACEAE

### EURYA Thunberg

EURYA GROFFII sp. nov.

Frutex vel arbor parva; ramis teretibus, glabris, ramulis pilosis; foliis lanceolatis, chartaceis vel subcoriaceis, usque ad 6 cm longis et 1.2 cm latis, nitidis, supra glabris, subtus pilosis, apice tenuiter acuminatis, basi obtusis, plerumque leviter inaequilateralibus, costa supra impressa, subtus cum venis prominulis; fructibus axillaribus, fasciculatis, globosis vel ovoideis, glabris, stylis connatis; sepalis elliptico-ovatis, exterioribus leviter pilosis, coriaceis, 1.5 ad 2 mm longis.

A shrub or a small tree, the branchlets rather densely pilose. Branches terete, glabrous, dark reddish brown. Leaves numerous, lanceolate, chartaceous to subcoriaceous, greenish olivaceous and shining when dry, 3.5 to 6 cm long, 8 to 12 mm wide, the margins denticulate, the upper surface glabrous, the lower pilose, the midrib above impressed, prominent beneath, the lateral nerves obsolete or subobsolete on the upper surface, distinct and somewhat projecting on the lower surface, the apex slenderly acuminate, the base obtuse and often minutely inequilaterally cordate, sessile or subsessile. Fruits axillary, glabrous, globose or ovoid, 3 to 3.5 mm in diameter, smooth, their pedicels 1 to 1.5 mm long; styles united for the lower 1 mm, the arms about 1 mm long. Sepals coriaceous, elliptic-ovate, 1.5 to 2 mm long, rounded, the outer ones somewhat pilose.

Kwangtung Province, Tiu Kaan Shan, Tseng Uen, *Groff 2378*, March, 1918, on mountain sides.

In vegetative characters and general appearance this species strongly resembles *Eurya swinglei* Merr., but differs radically in its entirely glabrous fruits and much shorter styles. From *Eurya distichophylla* Hemsl. it is readily distinguished by its slenderly acuminate leaves and the veins obsolete or nearly so on the upper surface and projecting on the lower surface. The fruits and staminate flowers of Hemsley's species are as yet unknown.

## FLACOURTIACEAE

### XYLOSMA Forster f.

XYLOSMA CONGESTUM (Lour.) comb. nov.

*Croton congestum* Lour. Fl. Cochinch. (1790) 582, excl. descr. fruct.
*Xylosma racemosum* Miq. Ann. Mus. Bot. Lugd.-Bat. 2 (1865–66) 155.
*Hisingera racemosa* Sieb. & Zucc. Fl. Jap. Fam. Nat. 1 (1843) 169.
*Xylosma japonicum* A. Gray in Mem. Amer. Acad. II 6[1] (1863) 381
*Flacourtia chinensis* Clos. in Ann. Sci. Nat. Bot. IV 8 (1857) 219.

This species is very common in thickets in the vicinity of Canton, Loureiro's type having been from Canton. J. Mueller[11] notes that Loureiro's description of the flowers and of the inflorescences does not conform to *Croton;* further it does not conform with the characters of any euphorbiaceous plant known from Kwangtung Province, but, with the exception of the fruit description, agrees entirely with the species currently known as *Xylosma racemosum* Miq. It is clear that Loureiro either added the fruit description to make his species agree with the generic characters of *Croton*, or described the fruits from material originating from a species entirely unrelated to the flowering specimen described by him. I have examined the following specimens from Kwangtung Province, mostly from the immediate vicinity of Canton: *Merrill 9850, 9993, Groff 2252, 2353, Levine 18, 171, 172, 177, 279, 365, 366, 371, 1749, 1809, 1829, 2084, 3261, 3341, To Kang P'eng 2727, 2737.* The local names recorded are *wu ying shue* (vicinity of Canton), *ch'ui tung ts'ai* (North River region), and *chü nga lak shü* (Kochow region). The name *pa tau* recorded by Loureiro should probably be excluded as it is the same as the name recorded by him for *Croton tiglium* Linn.

## THYMELAEACEAE

### AQUILARIA Lamarck

AQUILARIA SINENSIS (Lour.) comb. nov.

*Ophiospermum sinense* Lour. Fl. Cochinch. (1790) 281.
*Aquilaria chinensis* Spreng. Syst. 2 (1825) 356.
*Aquilaria grandiflora* Benth. Fl. Hongk. (1861) 297.

Loureiro cites no definite locality, but from the fact that he indicated the local name *pa mou yong* as Chinese it is clear that his material was from China, and in all probability from the vicinity of Canton. The description definitely applies to the species commonly known as *Aquilaria grandiflora* Benth., one that is not uncommon in the vicinity of Canton. Loureiro's description of the perianth as 6-merous was apparently due to an error on his part, for he enumerates the stamens as five, thus indicating that he was describing a 5-merous flower. I have examined the following Kwangtung material: *Groff 2487, Merrill 10962, Levine 996, 1400, 2070*, from Tsangsheng, Wa Shau Toi, White Cloud Mountain, and Honam Island, the last two localities being in the immediate vicinity of Canton. Loureiro's

[11] DC. Prodr. $15^{2}$ (1866) 696.

type is preserved in the herbarium of the Paris Museum and is identical with the species as here interpreted.

## RHIZOPHORACEAE

### CARALLIA Roxburgh

CARALLIA BRACHIATA (Lour.) comb. nov.

*Diatoma brachiata* Lour. Fl. Cochinch. (1790) 296.
*Carallia lucida* Roxb. Hort. Beng. (1814) 92, *nomen nudum*, Pl. Coromandel 3 (1819) 8, *t. 211*.
*Carallia integerrima* DC. Prodr. 3 (1828) 33.
*Petalotoma brachiata* DC. op. cit. 295.

Kwangtung Province, White Cloud Mountain, near Canton, *Levine 3386*, local name *nik nga tsai;* Poon Yue District, *Levine 3138;* Kochow region, *To Kang P'eng 2676, 2751*, with the local name *ngo shen muk.*

Loureiro's generic name has priority over *Carallia*, but the latter is retained in the list of *nomina conservanda* adopted by the Vienna Botanical Congress. *Petalotoma* DC. is merely a new generic name for *Diatoma*. I believe Loureiro's description applies to the common and widely distributed Indo-Malayan species commonly known as *Carallia lucida* Roxb. and as *C. integerrima* DC., the last two certainly being conspecific.

## MYRTACEAE

### EUGENIA Linnaeus

EUGENIA BULLOCKII Hance in Journ. Bot. 16 (1878) 227.

Kwangtung Province, Kochow region, Shek Tan Kong, *To Kang P'eng 2995*, March, 1919.

This specimen, although in fruit, agrees closely with the original description and with Hainan material collected by Miss Moninger, which I have identified with Hance's species. It was previously known only from Hainan.

## ARALIACEAE

### ARALIA Linnaeus

ARALIA SPINIFOLIA sp. nov. § *Arborescentes*.

Frutex erectus, circiter 3 m altus, foliis inflorescentiisque perspicue spinosis atque setosis; foliis magnis, bipinnatis, pinnis circiter 30 cm longis, 5- ad 9-foliolatis; foliolis oblongo-ovatis, usque ad 12 cm longis, membranaceis, acuminatis, brevissime petiolulatis, basi rotundatis, serratis, utrinque ad costa nervisque parce spinosis atque setosis; inflorescentiis magnis, laxis,

umbellulis longe pedunculatis; fructibus ovoideis, 5 mm longis, glabris, 5-carinatis, perspicue 5-sulcatis, pedicellis 1 ad 1.5 cm longis.

An erect shrub about 3 m high. Leaves large, bipinnate, the rachis, partial rachises, and leaflets on both surfaces with scattered, long, slender, nearly straight spines and with more numerous, slender, spreading setae, the spines 3 to 10 mm long, the setae 1.5 to 3 mm in length. Pinnae 5- to 9-foliolate, about 30 cm long; leaflets oblong-ovate, membranaceous, dark brown or olivaceous when dry, the lower surface somewhat paler than the upper, 9 to 12 cm long, 4 to 6 cm wide, subsessile, base rounded, often slightly inequilateral, apex acuminate, margins serrate, the teeth apiculate, the spines few, scattered, and mostly confined to the midrib with a few on the primary nerves, fewer on the lower surface than on the upper, the setae more numerous and scattered all over the epidermis on both surfaces. Inflorescences ample, lax, the ultimate branchlets up to 10 cm in length. Umbels subglobose, about 30 fruits in each, the pedicels 10 to 15 mm long, setose. Fruits ovoid, glabrous, about 5 mm long, prominently 5-keeled and deeply 5-sulcate, the depressions broad, rounded.

Kwangtung Province, Chan Tung hill, *Levine 3242*, October 30, 1918, with the local name *lak cha tsui*.

This species is readily distinguished among its congeners by its spiny and setose rachises, partial rachises, leaflets, and inflorescences.

## PRIMULACEAE

### LYSIMACHIA Tournefort

**LYSIMACHIA CANDIDA** Lindl. var. **DEPAUPERATA** var. nov.

A typo differt planta multo minoribus 5 ad 8 cm altus, foliis oblanceolatis ad obovatis, 5 ad 15 cm latis, obtusis vel subacutis, pedicellis quam floribus haud longioribus.

Kwangtung Province, Kochow region, Fung Mun, *To Kang P'eng 2735*, February 22, 1919, in fields.

**LYSIMACHIA ALFREDI** Hance in Journ. Bot. 15 (1877) 356; Pax & Knuth in Engl. Pflanzenreich 22 (1905) 281.

Kwangtung Province, Shiuchow region, *To Kang P'eng 2858*, *Levine 3524*, April, 1919, in woods.

The identification has been made from the descriptions, the former number cited agreeing better with it than the latter, although differing in some details. The species has previously been known only from Fokien Province.

## EBENACEAE

### DIOSPYROS Linnaeus

**DIOSPYROS SINENSIS** Hemsl. in Journ. Linn. Soc. Bot. 26 (1889) 71.

Kwangtung Province, Shiuchow region, *To Kang P'eng 2785, 2788.*

Previously known from Szechuen and Hupeh Provinces, but not before reported from as far south as Kwangtung.

## SYMPLOCACEAE

### SYMPLOCOS Jacquin

**SYMPLOCOS FUSONII** sp. nov. § *Hopea, Lodhra.*

Frutex 2 ad 3 m altus, ramulis castaneo- vel purpureo-pubescentibus, inflorescentiis cinereo-pubescentibus. Foliis coriaceis vel subcoriaceis, glabris, ellipticis ad oblongo-ellipticis, usque ad 5.5 cm longis, nitidis, margine minute glanduloso-serrulatis vel crenulatis, deorsum integris, apice acutis vel brevissime acuminatis, basi acutis, nervis utrinque 5 vel 6, anastomosantibus, costa supra haud impressa; racemis axillaribus, solitariis vel binis, paucifloris, 8 ad 10 mm longis, floribus omnibus pedicellatis; fructibus oblongo-ovoideis, leviter adpresse pubescentibus, circiter 5 mm longis. Species *S. anomalae* affinis.

A shrub 2 to 3 m high, the branches reddish brown, glabrous, the branchlets slender, somewhat angled, castaneous or purplish, appressed-pubescent with short hairs. Leaves coriaceous or subcoriaceous, shining, glabrous, elliptic to oblong-elliptic, 3 to 5 cm long, 1.5 to 3 cm wide, the apex acute or shortly acuminate, base acute, margins minutely glandular-serrulate or crenulate, toward the base usually entire; lateral nerves 5 or 6 on each side of the midrib, slender, anastomosing, the reticulations lax, the midrib not impressed on the upper surface; petioles 2 to 3 mm long, glabrous or when young pubescent. Racemes axillary, solitary, or in pairs, short, few-flowered, appressed cinereous-pubescent, 8 to 10 mm long, simple, usually 5 to 10 flowers in a raceme. Flowers white, their pedicels 1.5 to 2.5 mm long, the apical bracteoles triangular-ovate, acute, about 1 mm long, somewhat pubescent. Calyx pubescent, the tube short, the limb 2.5 mm in diameter, the lobes orbicular-reniform, spreading, rounded, slightly pubescent, about 1 mm long and 1.2 mm wide. Petals glabrous, oblong-elliptic, 3 mm long. Stamens indefinite, the filaments glabrous, 3 to 4 mm long, slightly united below, forming about 5 indistinct phalanges. Ovary 3-celled; style gla-

brous, 5 mm long. Fruits sparingly appressed-pubescent, oblong-ovoid, terete, about 5 mm long.

Kwangtung Province, Kochow region, Lai Tung and Shan Mi, *To Kang P'eng 2714* (type), *2677*, February and March, 1919, the former with the local name *ye cha fa*.

This species, dedicated to Mr. C. G. Fuson, through whose interest it was possible to do some field work in the Kochow region, is distinctly allied to *Symplocos anomala* Brand of Yunnan Province, from which it differs in its shorter, much less acuminate, fewer-nerved leaves, and somewhat longer, more numerously flowered racemes.

SYMPLOCOS CHINENSIS (Lour.) Desvaux MS. in herb. Mus. Paris. comb. nov.

*Myrtus chinensis* Lour. Fl. Cochinch. (1790) 313.
*Symplocos sinica* Ker in Bot. Reg. 9 (1823) *t. 710;* Brand in Engl. Pflanzenreich 6 (1901) 34.

Loureiro's material was from the vicinity of Canton, and his description applies unmistakably to the species currently known as *Symplocos sinica* Ker. It is common on hills near Canton and is represented by the following Kwangtung material: *Merrill 10725, Levine 15, 294, 637, 1787, 2372, 3198, 3403.* The only recorded local name is *hak tsz* in the Lin District; Loureiro records the Cantonese name as *tan quat xiong.* Among the other new genera and species described by Loureiro *Dicalyx cochinchinensis* Lour. is *Symplocos cochinchinensis* Moore; *Decadia aluminosa* Lour. is apparently identical with *Symplocos spicata* Roxb.; *Drupatris cochinchinensis* Lour. is certainly a *Symplocos;* and *Myrtus zeylanica* Lour. (non Linn.) is probably a *Symplocos.* Loureiro's type of *Myrtus chinensis* is preserved in the herbarium of the Paris Museum of Natural History.

## LOGANIACEAE

### STRYCHNOS Linnaeus

STRYCHNOS UMBELLATA (Lour.) comb. nov.

*Cissus umbellata* Lour. Fl. Cochinch. (1790) 84.
*Strychnos paniculata* Champ. in Hook. Kew Journ. Bot. 5 (1853) 56.

Planchon,[12] in excluding Loureiro's species from the Vitaceae, suggests that it might be a *Strychnos.* I am of the opinion that this is the correct disposition of *Cissus umbellata* Lour., and

[12] DC. Monog. Phan. 5 (1887) 626.

further that it is identical with *Strychnos paniculata* Champ., a species strongly characterized by its 4-merous flowers and the only representative of the genus known from the vicinity of Canton.

### LIGUSTRUM Linnaeus

**LIGUSTRUM GROFFIAE** sp. nov.

Frutex circiter 2 m altus, subtus foliis et ramulis et inflorescentiis perspicue molliterque ferrugineo-villosis; foliis oblongo-ovatis, usque ad 7 cm longis, acuminatis, basi acutis, supra olivaceis, nitidis, leviter pubescentibus, subtus pallidioribus, nervis utrinque circiter 6, tenuibus; inflorescentiis axillaribus, paniculatis, 5 ad 6 cm longis, ramis inferioribus usque ad 3 cm longis; floribus numerosis, corolla 4 mm longa, glabra, tubo 2 mm longo.

A shrub about 2 m high, the leaves on the lower surface and especially the branchlets and inflorescences densely and softly ferruginous-villous with spreading hairs. Branches terete, those up to 5 mm in diameter more or less pubescent, the ultimate branchlets about 2 mm in diameter. Leaves chartaceous, oblong-ovate, 5 to 7 cm long, 2.5 to 3 cm wide, apex acuminate, base acute, the upper surface olivaceous, shining, somewhat pubescent, the midrib and nerves impressed, the lower surface paler, softly villous; lateral nerves about 6 on each side of the midrib, slender; petioles 4 to 5 mm long, ferruginous-villous. Panicles axillary, 5 to 6 cm long, many-flowered, the branches usually spreading, the lower ones up to 3 cm in length. Flowers white, fragrant, their pedicels 1 to 2 mm long, glabrous; bracteoles oblong-lanceolate, somewhat acuminate, about 1 mm long. Calyx somewhat cup-shaped, glabrous, 1 to 1.2 mm long, shallowly 4-toothed. Corolla 4 mm long, the tube 2 mm long, the lobes somewhat elliptic, obtuse. Stamens exserted.

Kwangtung Province, Shiuchow region, Tan Ha Shan, *To Kang P'eng 2820*, April 24, 1919, with the local name *mo ch'ung shü*. Possibly referable to this species is *No. 2795* of the same collection from the same locality with the local name *sha yeuk shu;* this specimen, however, has much smaller leaves and much-fewer flowered inflorescences than the type.

This species is well characterized by its dense ferruginous-villous indumentum. It is dedicated to Miss Elizabeth H. Groff, through whose interest it was possible to have collections made in the Shiuchow region.

## ASCLEPIADACEAE

### CRYPTOLEPIS R. Brown

CRYPTOLEPIS SINENSIS (Lour.) comb. nov.

*Pergularia sinensis* Lour. Fl. Cochinch. (1790) 169.
*Emericia sinensis* Roem. & Schultes Syst. 4 (1819) 402.
*Pergularia chinensis* Spreng. Syst. 1 (1825) 836.
*Vallaris sinensis* G. Don Gen. Syst. 4 (1838) 79.
*Cryptolepis elegans* Wall. Cat. (1829) No. 1639, *nomen nudum*, G. Don Gen. Syst. 4 (1838) 82.
*Aganosma edithiae* Hance in Ann. Sci. Nat. Bot. V 5 (1866) 227.

Loureiro's material was from China, presumably from the vicinity of Canton, and has long been considered a species of doubtful status. All the synonyms cited above, except the last two, are based on Loureiro's binomial. The description applies closely to the species currently known as *Cryptolepis elegans* Wall., a species not uncommon in Kwangtung Province and represented by the following specimens: *Merrill 10806, Levine 356, 1850, 3201*. Loureiro described the seeds as naked, perhaps because he saw only those from which the coma had fallen, or perhaps because he really saw no seeds. I am convinced, however, that the species as here interpreted is the one Loureiro intended.

## APOCYNACEAE

### ALYXIA Banks

ALYXIA LEVINEI sp. nov.

Frutex scandens, glaber, ramis ramulisque tenuibus, olivaceis; foliis oppositis et ternatis, junioribus membranaceis, vetustioribus chartaceis ad subcoriaceis, ellipticis ad oblongis, usque ad 8 cm longis, utrinque subaequaliter angustatis, obtuse acuminatis; inflorescentiis axillaribus brevibus, breviter pedunculatis, ut videtur paucifloris; fructibus junioribus ellipsoideis, circiter 9 mm longis.

A scandent glabrous shrub, the branches and branchlets slender, the internodes up to 25 cm in length, branchlets 1.5 mm in diameter or less, somewhat angled or striate, the older branches terete, smooth, somewhat reddish brown. Leaves opposite and in whorls of three, elliptic to oblong, 5 to 8 cm long, 2 to 3 cm wide, the younger ones membranaceous, the older ones chartaceous to subcoriaceous, olivaceous, shining, subequally narrowed to the acute or somewhat acuminate base and to the bluntly acuminate apex, the nerves often obsolete, never prominent; petioles 4 to 7 mm long. Inflorescences axillary, solitary, short, apparently very few-flowered, their peduncles 5 mm long

or less, obscurely puberulent, the persistent sepals oblong, 1.5 mm long. Young fruit ellipsoid, about 9 mm long.

Kwangtung Province, Ting Woo Mountain, *Levine 1975*, May 26, 1918, scattered along the banks of streams, altitude about 300 meters.

This is the second species of the genus to be found in Kwangtung Province and differs remarkably from *Alyxia sinensis* Champ. in its much larger, differently shaped, acuminate leaves.

## LABIATAE

### PRUNELLA Linnaeus

**PRUNELLA VULGARIS** Linn. Sp. Pl. (1753) 600.

Kwangtung Province, Shiuchow region, *To Kang P'eng 2854*, April 25, 1919, with the local name *ha fú ts'o*.

A widely distributed species in the North and South Temperate Zones. Central and northern China and Formosa, but not previously recorded from Kwangtung Province.

## BORAGINACEAE

### TRIGONOTIS Steven

**TRIGONOTIS PEDUNCULARIS** (Trev.) Benth. ex Baker & Moore in Journ. Linn. Soc. Bot. 17 (1879) 384.

*Myosotis peduncularis* Trev. in Schrift. Naturf. Ges. Berl. 7 (1813) 147.

Kwangtung Province, Shiuchow region, *Levine 3548*, along roads, May, 1919.

The genus is new to Kwangtung Province, the species being common in central and northern China, the present locality being far south of its previously known range.

## BIGNONIACEAE

### DOLICHANDRONE Seemann

**DOLICHANDRONE STIPULATA** (Wall.) Benth. ex C. B. Clarke in Hook. f. Fl. Brit. Ind. 4 (1884) 379.

*Spathodea stipulata* Wall. Cat. (1832) No. 6518, *nomen nudum*, Pl. As. Rar. 3 (1832) 20, *t. 238*.

Kwangtung Province, Kochow region, Kwanshan temple, *To Kang P'eng 2726*, February 18, 1919, with the local name *man mi muk*.

The Kwangtung specimen is with mature fruits and agrees closely with the description. The species was previously known only from Burma.

## ACANTHACEAE

### HEMIGRAPHIS Nees

**HEMIGRAPHIS PROCUMBENS** (Lour.) comb. nov.

*Barleria procumbens* Lour. Fl. Cochinch. (1790) 377.
*Ruellia chinensis* Nees in DC. Prodr. 11 (1847) 147.
*Hemigraphis chinensis* T. Anders. in Journ. Linn. Soc. Bot. 26 (1890) 238.
*Strobilanthes scaber* Hance in Journ. Bot. 16 (1878) 231, non Nees.

Loureiro's material was from the vicinity of Canton, where the species is still common, and on account of its yellow flowers is rather conspicuous in dry thickets. His description applies unmistakably to the species currently known as *Hemigraphis chinensis* T. Anders. It is represented by *Merrill 10135* and *Levine 181*.

## CAPRIFOLIACEAE

### LONICERA Linnaeus

**LONICERA DASYSTYLA** Rehder in Rept. Mo. Bot. Gard. 14 (1903) 158, *t. 4, f. 1–3.*

Kwangtung Province, North River, Sai Sha, Sz Ooi, *Groff 2402*, April 24, 1918, with the local name *kam ngan fa*.

The specimen agrees closely with Rehder's figure and description, differing in but few minor details. The leaves average smaller than in the type and are glabrous, while the older branchlets are brownish rather than grayish. The pubescent style is characteristic. Previously reported only from Tonkin.

## CUCURBITACEAE

### GYMNOPETALUM Arnott

**GYMNOPETALUM CHINENSE** (Lour.) comb. nov.

*Euonymus chinensis* Lour. Fl. Cochinch. (1790) 156.
*Bryonia cochinchinensis* Lour. op. cit. 595.
*Gymnopetalum cochinchinense* Kurz in Journ. As. Soc. Beng. 40[2] (1871) 57; Cogn. in DC. Monog. Phan. 3 (1881) 391.

Both of Loureiro's descriptions apply unmistakably to the species currently known as *Gymnopetalum cochinchinense* Kurz, and it is indeed curious that he should have placed a cucurbitaceous plant in the celastraceous genus *Euonymus*. The type of *Euonymus chinensis* was from the vicinity of Canton, for which Loureiro records the Cantonese name *kam qua*. It is represented by the following recently collected material from the vicinity of Canton, with the recorded names *ka shui kwah* and *ye kwah, Levine 1108, 1705, 2183*.

## RUBIACEAE

### PLECTRONIA Linnaeus

**PLECTRONIA LEVINEI** sp. nov.

Frutex glaber, ramis spinis longis rigidis rectis armatis; foliis chartaceis, ellipticis ad oblongo-ellipticis, 1.5 ad 4 cm longis, obtusus ad acutis, basi angustatis, acutis, nervis utrinque 2 vel 3, obscuris, subtus in axillis subobsolete glandulosis, reticulis obsoletis; fructibus axillaribus, solitariis, tenuiter pedicellatis, ovoideis, in siccitate nigris vel pruinosis, rugosis, circiter 6 mm longis.

A glabrous shrub, the branches terete or the ultimate branchlets obscurely angled. Leaves usually in pairs on two very short opposite branchlets, appearing like four leaves at each node, chartaceous, elliptic to oblong-elliptic, or sometimes somewhat obovate, rather pale when dry, slightly shining, 1.5 to 4 cm long, 1 to 2 cm wide, obtuse to acute, base narrowed, acute; lateral nerves 2 or 3 on each side of the midrib, slender, indistinct, their axils obscurely glandular on the lower surface, the reticulations obsolete; petioles 1 to 2 mm long; stipules about 1 mm long. Fruits axillary, solitary, black or somewhat pruinose, rugose, ovoid, about 6 mm long, when young crowned by the cylindric, 5-toothed, about 4 mm long calyx-tube, this soon deciduous, the pedicels 10 to 12 mm long, slender. Seeds usually two. Spines straight or slightly curved, stiff, rather slender, sharp, 1 to 1.5 cm long.

Kwangtung Province, Heung Shan District, near Macao, *Levine 3487*, January 18, 1919.

This species belongs in the group with *Plectronia horrida* Benth. & Hook. f., *P. parvifolia* Benth. & Hook. f., and *P. parviflora* Bedd., but is readily distinguished by being entirely glabrous, and by its solitary, slenderly pedicelled fruits.

### WENDLANDIA Bartling

**WENDLANDIA CHINENSIS** sp. nov.

Species *W. paniculatae* affinis, differt stipulis hirsutis, inflorescentiis densissime cinereo-villosis, floribus dense confertis, glomeratim dispositis, more *W. tinctoriae*.

A shrub or small tree up to 8 m high, the branches glabrous or nearly so, the branchlets more or less brownish- or cinereous-pubescent. Leaves chartaceous, oblong-elliptic to oblong-lanceolate, olivaceous and shining when dry, 10 to 12 cm long, 3 to 5 cm wide, subequally narrowed to the acute base and rather slenderly acuminate apex, the upper surface very slightly sub-

strigose-hirsute with widely scattered, short hairs, the lower surface sparingly pubescent with widely scattered, short, cinereous hairs on the midrib, nerves, reticulations, and epidermis; lateral nerves about 10 on each side of the midrib, distinct; petioles 5 to 10 mm long; stipules coriaceous, persistent, orbicular-reniform, somewhat hirsute, 7 to 9 mm wide, rounded, sometimes contracted below and distinctly stipitate. Panicles terminal, ample, up to 20 cm long and wide, densely cinereous-villous. Flowers very numerous, densely crowded in glomerules on the ultimate branches; bracts 5 to 7 mm long. Calyx densely cinereous-villous, about 2.5 mm long, the lobes oblong. Corolla-tube 4 to 5 mm long, slender, glabrous externally, sparingly pubescent within.

Kwangtung Province, Kochow region, Shek Kau Tong, *To Kang P'eng 2691* (type), March 6, 1919. To this species I also refer the following specimens, both described as shrubs about 2 m high, both with somewhat smaller leaves than the type and with unopened flowers: *To Kang P'eng 2754, 2702,* the former from Sheung Ko Wan, with the local name *fo shiu nap,* the latter from Shek Ling, with the local name *chü lüt shü.*

This species is manifestly allied to *Wendlandia paniculata* (Roxb.) DC., the type of which was from the Molucca Islands. Comparison with Amboina material, *Robinson 1731,* representing the typical form of Roxburgh's species, shows that the Chinese form differs radically in its very densely cinereous-villous inflorescences and calyces, and in its very densely crowded flowers, in the disposition of the flowers strongly resembling *Wendlandia tinctoria* DC. The Chinese form described by Hance as *Wendlandia uvariifolia* has been reduced to *Wendlandia paniculata* DC. It is represented by *Levine 2338,* from the North River region, and is distinctly different from *Wendlandia paniculata* and I believe should be retained as of specific rank under Hance's name. It differs from both *Wendlandia paniculata* DC. and *W. chinensis* Merr. in its leaves being rather densely ferruginous-pubescent beneath, while the disposition of the flowers and the indumentum of the inflorescences and calyces are quite different from the latter species.

### MUSSAENDA Linnaeus

MUSSAENDA PARVIFLORA Miq. Ann. Mus. Bot. Lugd.-Bat. 3 (1867) 110.

Kwangtung Province, Ting Woo Mountain and at Wan Lo Mountain, Kochow region, *Levine 1979, To Kang P'eng 2692,* April, 1918, and March, 1919.

The specimens agree closely with Formosan material and also conform to Miquel's description. I believe this to be, at least in part, the Kwangtung form referred by Dunn and Tutcher to *Mussaenda frondosa* Linn., but I have seen no Chinese material at all approaching the typical Ceylon form of the Linnean species.

### RANDIA Linnaeus

**RANDIA ACUMINATISSIMA** sp. nov.

Arbor parva, usque ad 8 mm alta, ramulis et inflorescentiis et subtus foliis ferrugineo-pubescentibus; foliis chartaceis, oblongo-ellipticis ad oblongo-lanceolatis, usque ad 20 cm longis, utrinque angustatis, basi acutis, apice tenuiter caudato-acuminatis, supra in siccitate olivaceis, glabris, nitidis; nervis utrinque 10 ad 12, subtus perspicuis; stipulis lineari-lanceolatis, acuminatis, usque ad 1 cm longis; cymis oppositifoliis, 3 ad 4 cm longis, breviter pedunculatis; floribus ad apices ramulorum confertis, calycis segmentis lanceolatis, acuminatis, circiter 1.5 mm longis; fructibus globosis, glabris, 6 ad 8 mm diametro, in siccitate nigris, nitidis; seminibus numerosis, compressis, circiter 1.5 mm diametro.

A small tree about 8 m high, the branchlets, inflorescences, and the lower surface of the leaves rather densely ferruginous-pubescent. Branches dark reddish brown, usually terete, glabrous. Leaves oblong-elliptic to oblong-lanceolate, chartaceous, 11 to 20 cm long, 4 to 7 cm wide, subequally narrowed below to the acute, equilateral base, and above to the slenderly caudate-acuminate apex, the acumen sometimes falcate, the upper surface glabrous, olivaceous and shining when dry, the lower surface rather softly pubescent; lateral nerves 10 to 12 on each side of the midrib, prominent on the lower surface, anastomosing, the reticulations rather lax, distinct; petioles usually pubescent, 5 to 8 mm long; stipules linear-lanceolate, acuminate, pubescent, up to 1 cm long. Cymes leaf-opposed, shortly peduncled, ferruginous-pubescent, 3 to 4 cm long (corollas unknown), the flowers sessile or shortly pedicelled and somewhat crowded at the tips of the branchlets. Calyx ferruginous-pubescent, about 4 mm long, the lobes lanceolate, acuminate, about 1.5 mm long. Fruits globose, glabrous, 6 to 8 mm in diameter, black and shining when dry. Seeds many, flattened, orbicular-ovate to ovate, about 1.5 mm long.

Kwangtung Province, White Cloud Mountain, *Levine 3130* (*type*) *3267*, August 29, November, 1918; Kong Moon, *Groff*

*2471*, March, 1918; Ukantin, *Hongkong Herbarium 10918*, distributed as *Randia densiflora* Benth.

This species is manifestly allied to *Randia racemosa* (Cav.) F.-Vill. (*R. densiflora* Benth.), from which it is easily distinguished by its indumentum.

## COMPOSITAE

### GYNURA Cassini

**GYNURA SEGETUM** (Lour.) comb. nov.

*Cacalia segetum* Lour. Fl. Cochinch. (1790) 486, in nota.
*Cacalia pinnatifida* Lour. l. c. non Linn.
*Gynura pinnatifida* DC. Prodr. 6 (1837) 301.

Kwangtung Province, Kochow region, Kwong T'am Mountain, *To Kang P'eng 2671*, March 22, 1919, in a garden, with the local name *tung fung ip*.

The type of Loureiro's species was from Canton, where he observed it growing in rice paddies. He records the Cantonese name as *cien fan sat*. His description applies closely to the specimen cited above. I consider his specific name *pinnatifida* to be invalidated by the earlier *Cacalia pinnatifida* Linn., an entirely different species, and hence adopt the casual name published by him: "unde vernaculum nomen Sinense *Cacalia Segetum*."

### CROSSOSTEPHIUM Lessing

**CROSSOSTEPHIUM CHINENSE** (Linn.) comb. nov.

*Artemisia chinensis* Linn. Sp. Pl. (1753) 649, excl. syn. Gmelin; Lour. Fl. Cochinch. (1790) 492.
*Artemisia judaica* Lour. Fl. Cochinch. (1790) 489, non Linn.
*Crossostephium artemisioides* Less. ex Cham. & Schlecht. in Linnaea 6 (1831) 220.

The genus *Crossostephium* was based on cultivated specimens from Manila and from Canton, the species being widely cultivated in Japan, China, the Philippines, and Indo-China. I have seen no specimens from wild plants, although the species is manifestly a native of either China or Japan. It is currently known in Manila, where it is cultivated in pots, as *ajenjo*, a Spanish name properly belonging to *Artemisia*. The type of the Linnean species was a specimen collected in China by Lagerstroem, and the Linnean description based on this specimen clearly applies to the species currently known as *Crossostephium artemisioides* Less. The species is still common in cultivation in Canton. Both of Loureiro's descriptions cited above apply to this species.

### EMILIA Cassini

EMILIA PRENANTHOIDEA DC. Prodr. 6 (1837) 303.

Kwangtung Province, Teng Woo Mountain, *Levine 2041, 3221,* May 26, 1918.

India to the Philippines; this species has previously been tentatively recorded from China by Forbes and Hemsley,[13] who state that in preparing their list they had recorded the species from China on the basis of a specimen collected by Fortune, but that the specimen was not to be found at the time their manuscript was written. The species is readily distinguished from *Emilia sonchifolia* DC. not only by its narrow leaves, but also by its involucral bracts being much shorter than the flowers and by its glabrous achenes.

### SENECIO Tournefort

SENECIO OLDHAMIANUS Maxim in Bull. Acad. Pétersb. 16 (1871) 219.

Kwangtung Province, Shiuchow region, *To Kang P'eng 2852,* April 25, 1919, in grassy places.

Not previously recorded from Kwangtung Province; common in central China.

[13] Journ. Linn. Soc. Bot. 23 (1888) 449.

# NOTIZ UEBER HOYA IMBRICATA CALLERY EX DECAISNE UND HOYA PSEUDOMAXIMA KDS. IN DEN FILIPINEN AUF GRUND VON EINIGEN HERBAR-EXEMPLAREN DES BUREAU OF SCIENCE IN MANILA

Von S. H. KOORDERS

*Buitenzorg, Java*

MIT VIER TAFELN

1. HOYA IMBRICATA Callery ex Decaisne, forma TYPICA Kds. Taf. I.

Decaisne giebt in DC. Prodromus 8 (1844) 637 folgende von ihm in Delessert, Icones selectae plant. 5 (1846) 37 und später von Miquel, Flora Indiae Batav. 2 (1857) 520, unverändert übergenommene Spezies-Beschreibung von *Hoya imbricata:*

Scandens radicans, foliis abortu alternis unilateralibus imbricatis orbicularibus supra convexis aveniis subtus venosis marginibus reflexis, pedunculis multifloris, pedicellis gracilibus glabris, callyce brevi, corollae laciniis triangularibus acutis, coronae stam. fol. supra convexiusculis marginibus revolutis angulo int. porrecto antherumque membrana attenuata stigmati apiculato incumbentibus, folliculis laevibus. Frutex scandens arbor. truncis conjunctissime affixus. (Decne. l. c.)

Von dieser characteristischen, bisher im Buitenzorger Herbar fehlenden Art, erhielt ich leihweise aus dem Herbarium des Bureau of Science in Manila, von Herrn E. D. Merrill, folgendes von ihm in den Filipinen gesammeltes Herbar-Exemplar:

LUZON, Rizal Province, Tanay, *Merrill 2363*, ausgeblüht im Mai, 1903.

Dieses Exemplar ist von Merrill etikettiert: *Hoya imbricata* Dcne., und von ihm mit folgender Bemerkung versehen: "This should be typical *H. imbricata.* Leaves mottled, green and purple."

Das Exemplar wurde nach seiner Angabe von ihm gesammelt ziemlich nahe bei dem Fundort von den authentischen Exemplar von *Hoya imbricata* des Pariser Herbar. Es besteht aus einem Blütenzweig mit 4 sich dachziegelig deckenden Blättern und einem ausgeblühten Blütenstand, und einer Papierkapsel mit einem einzelnen Laubblatt.

Von allen mir aus dem Herbarium des Bureau of Science in Manila, unter dem Namen *Hoya imbricata* leihweise zuge-

schickten Herbarexemplaren, stimmt kein einziges so gut überein mit der Beschreibung und Abbildung von *Hoya imbricata* in DeCandolle Prodromus, und in Delessert, wie obengenanntes Spezimen (*Merrill 2363*), dass es als "Topotype" (im Merrillschen Sinne) von *Hoya imbricata* betrachtet werden darf.

Über dieses bemerkenswerte Herbarexemplar (*Merrill 2363*) lasse ich folgende Beschreibung folgen:

Blätter kreisrund, ± ganzrandig oder eckig-ausgeschweift, am Grunde abgerundet-abgestutzt, oben abgerundet oder emarginat; oberseits convex, ohne deutliche Nerven, völlig kahl und glatt (auch ohne Cuticular-Höcker); unterseits concav (auch ohne Cuticular-Höcker); ± in der Mitte dem sehr kurzen, fast fehlenden Blattstiel peltat inseriert und handnervig, mit undeutlichen, gabelig verzweigten Nerven; ± 9 cm lang und 10 cm breit. Epidermis des Blatt-Oberseite ohne Haare, mit ± glatter oder schwachwelliger etwa 20 $\mu$ dicker Cuticula, fast ohne Cuticular-Höcker und dadurch aussen glatt (nicht körnigrauh) aussehend. Epidermis Zellen des Blattes Unterseite je mit einem wagerecht abstehendem, einzelligem, unverzweigtem, fadenförmigem oder schmalkegelförmigem, spitzem, glattem, inhaltlosem, farblosem, gerade oder ± gekrümmtem, 30–50 $\mu$ langem Haar versehen und mit nur 5 $\mu$ dicker Cuticula. Stengel stielrund, ± 4 mm Durchmesser, kahl (auch ohne Papillen Cuticular-Höcker), mit zahlreichen, dichtstehenden Haftwurzeln, welche meistens ganz oder fast ganz von den dachig deckenden Laubblättern geschützt sind. Pedunculus axillar (in sicco abstehend), ± 10 cm lang, stielrund, kahl; rhachis ± 9 cm lang, kahl, dicht bedeckt mit den Narben der abgefallenen Pedicelli, spindelförmig, in der Mitte fast 1 cm breit.

Dieses Exemplar (*Merrill 2363*) ist von mir *Hoya imbricata* Callery ex Decaisne, forma *typica* Kds. (msc. 1918) etikettiert worden.

2. HOYA IMBRICATA Callery forma BASI-SUBCORDATA Kds. forma nov. Taf. II, III.

A typo recedit foliis basi subcordatis.

Blätter kreisrund, ± ganzrandig, oben abgerundet, am Grunde bis 1 cm (oft nur 0.5 cm) untief-herzförmig, ± in der Mitte peltat, dachig deckend, bisweilen (*Copeland 399*) auseinander entfernt. Blüten ± wie der Typus. Früchte unbekannt.

Die folgenden 3 Exemplare des Manila-herbars halte ich für diese neue Form (foliis basi-subcordatis) von *Hoya imbricata*:

BILIRAN, *Bur. Sci. 18893 McGregor*, blühend im Juni, 1914.

MINDANAO, Davao District, bei Davao, *Copeland 399*, blühend im März, 1904. SAMAR, *Bur. Sci. 24910 Edaño.*

Diese Exemplare stimmen Beide im Blütenbau mit der Beschreibung und Abbildung von *Hoya imbricata* in Decaisne gut überein, und besitzen ebenso wie auch *Merrill 2363*, beiderseits völlig kahle Blätter (die auch keine Cuticular-Höcker haben), jedoch ist der Blattfuss deutlich "subcordat". Die Tiefe des herzförmigen Blattfuss-Einschnittes beträgt ± 0.5–1 cm.

Die Blüten von *Bur. Sci. 18893 McGregor* sind noch nicht völlig ausgebildet und kleiner als von *Copeland 399*. Bei beiden Exemplaren liegen keine Früchte vor.

Mit obiger forma *basi-subcordata* zeigt folgendes Filipinen-Exemplar einige Ähnlichkeit, jedoch ist die Korolla auf innen auffallend dicht behaart: SAMAR, Catubig River, *Bur. Sci. 24910 Edaño.* Blühend im Februar-März, 1916. Diesem Exemplar ist von Merrill folgende Bemerkung hinzugefügt: "Flowers appear to be different from *Hoya imbricata*." Auch bei diesem Exemplar sind keine Früchte vorhanden. Vielleicht liegt hier eine von *Hoya imbricata* neue Spezie vor.

3. HOYA PSEUDOMAXIMA Kds. sp. nov. Taf. IV.

A *Hoya imbricata* Callery foliis basi profunde cordatis et a *Hoya maxima* Kds. foliis supra glaberrimis et apice haud raro emarginatis differt.

LUZON, Rizal Province, Bosoboso, *Bur. Sci. 22089 Ramos*, blühend am 7ten December, 1913.

Blätter kreisrund, am Grunde bis 3 cm tief-herzförmig, oberseits völlig kahl (nicht nur unbehaart, sondern auch ohne Cuticular-Höcker) und glatt, unterseits kahl und auch ohne Cuticular-Höcker, bis 8 cm lang und 9 cm breit. Blüten ± wie *Hoya imbricata*, Früchte unbekannt.

Bemerkung: Während bei allen (12) Einsammlungs-Nummern meiner *Hoya maxima* aus Nord-Ost-Celebes (*Kds. n. 16204* $\beta$, u.s.w.) die Blatt-Oberseite stets mit Cuticular-Höckern dicht bedeckt ist, welche dauernd oder seltener nur in der Jugend je ein Flaumhaar tragen, bei der nur aus den Filipinen (Mount Isarog) bekannten *Hoya pseudomaxima* ist die Blatt-Oberseite völlig glatt (glaberrima) ohne Cuticular-Höcker und ohne Flaumhaare.

## ERKLÄRUNG DER ABBILDUNGEN

[Originalzeichnung von Mangoendimedjo, direxit Koorders; Nachzeichnung von J. K. Santos.]

TAFEL I

*Hoya imbricata* Callery ex Decaisne, forma *typica* Kds.

FIG. 1. Blütenzweig mit ausgeblühtem Blütenstand, wovon alle Blüten abgefallen sind.
2. Blatt, Unterseite.
3. Ausgeblühter Blütenstand.
4. Querschnitt durch die Epidermis der Blatt-Oberseite.
5. Idem der Blatt-Unterseite. (Original, nach *Merrill 2363* in Herb. Bureau of Science in Manila. Gesammelt in den Filipinen, auf Luzon, in der Provinz Rizal bei Tanay, im ausgeblühtem Zustand, im Mai, 1903.) In dieser Gegend wurde nach der brieflichen Mittheilung von Merrill das Original von *Hoya imbricata* gesammelt. Damit stimmt Herb. *Merrill 2363* nach der Abbildung und nach der Beschreibung von Decaisne vorzüglich überein. Auf der Original-Einsammlungs-Etikette von *Merrill 2363* steht: "leaves mottled, green and purple." Ferner wurde von ihm auf seinem mir geliehenen Original-Herbarbogen folgendes erwähnt: "This should be typical *Hoya imbricata*."

TAFEL II

*Hoya imbricata* Callery forma *basi-subcordata* Kds.

FIG. 1. Blütenzweig, Unterseite.
2. Blattzweig, Oberseite.
3. Blattzweig, Unterseite.
4. Blütenstand.
5. Blüte. (Original, nach *Bur. Sci. 18893 McGregor.*)

TAFEL III

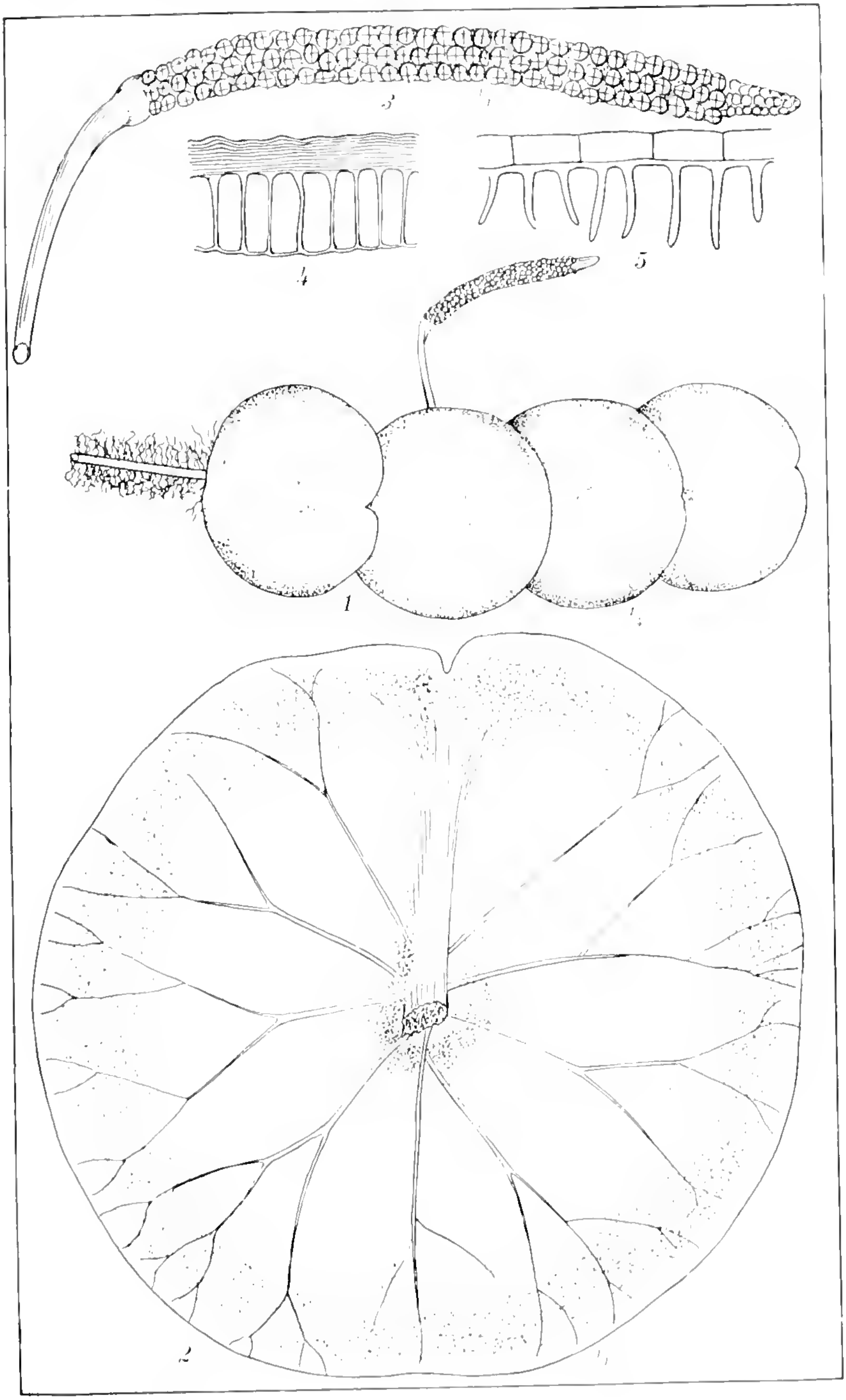
*Hoya imbricata* Callery forma *basi-subcordata* Kds.

FIG. 1. Blütenzweig, Unterseite.
2. Blüte.
3. Translatoren. (Original, nach *Copeland* 399.)

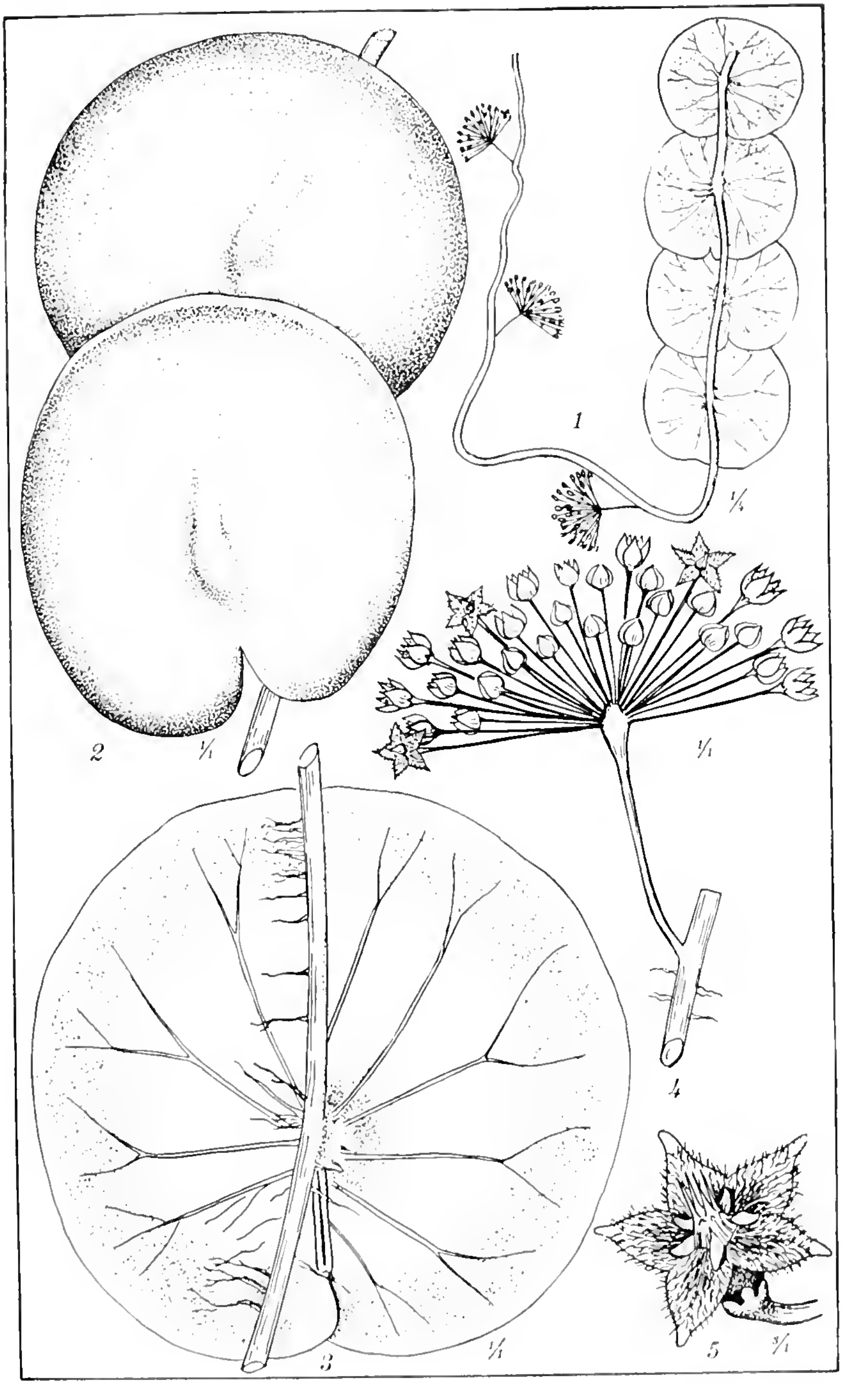
TAFEL IV

*Hoya pseudomaxima* Kds.

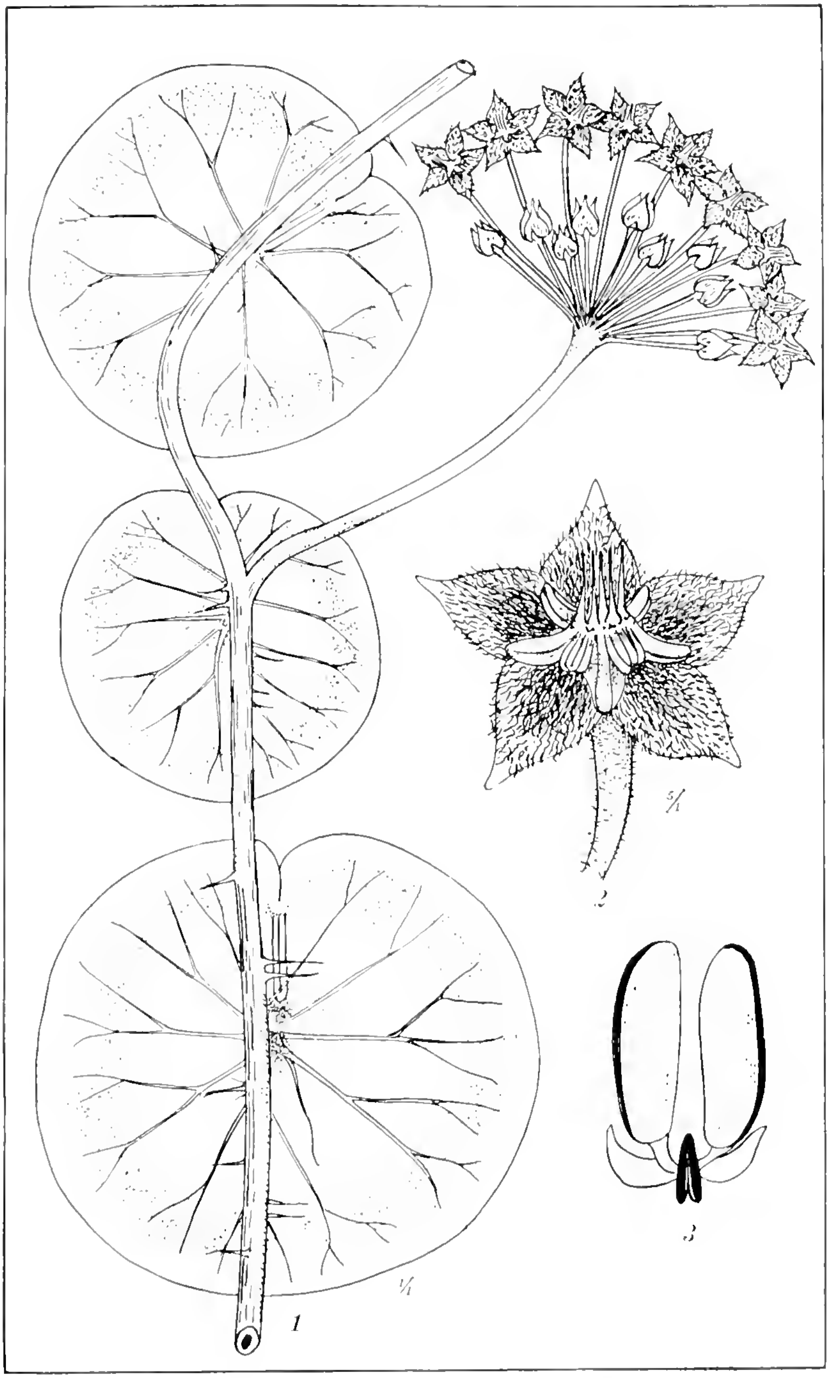
FIG. 1. Blattzweig, Oberseite.
2. Blüte.
3. Blüte.
4. Translatoren.
5. Blattzweig, Oberseite.
6. Blatt, Unterseite.
7. Blütenzweig.
8. Blüte. (Original, 1–4 nach *Bur. Sci. 970 Ramos;* 5–8 nach *Bur. Sci. 22089 Ramos.*)



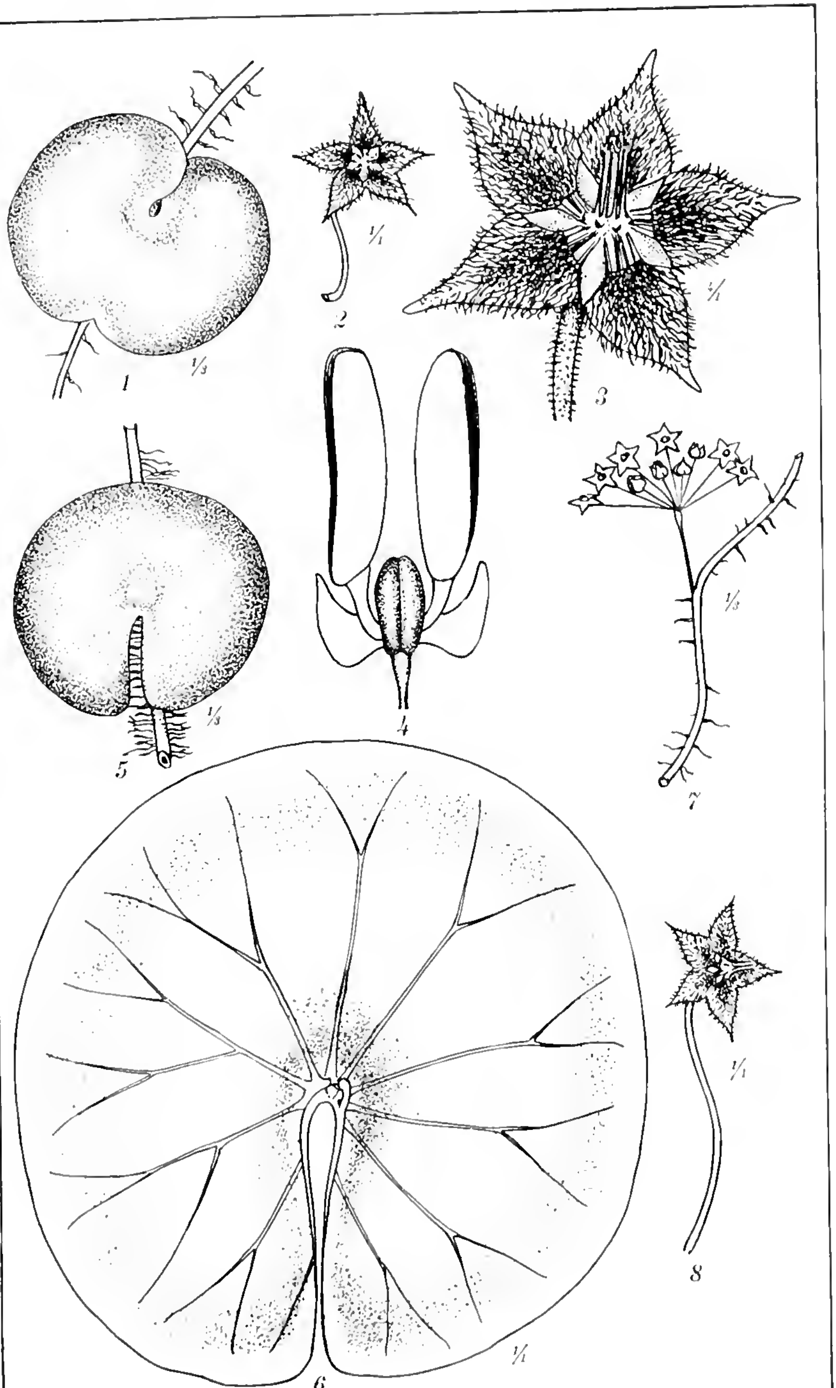

TAFEL I. HOYA IMBRICATA CALLERY EX DECAISNE, FORMA TYPICA KOORD.




TAFEL II. HOYA IMBRICATA CALLERY, FORMA BASI-SUBCORDATA KOORD.




TAFEL III. HOYA IMBRICATA CALLERY, FORMA BASI-SUBCORDATA KOORD.




TAFEL IV. HOYA PSEUDOMAXIMA KOORD.

# THE BLACK HALICTINE BEES OF THE PHILIPPINE ISLANDS

By T. D. A. COCKERELL

*Of the University of Colorado*

The black halictine bees of the Philippines have all been referred to the genus *Halictus;* but the subgenus *Nesohalictus*, of Crawford, remarkable for its very long tongue, may be elevated to generic rank.

## Genus NESOHALICTUS Crawford

*Halictus* subgenus *Nesohalictus* CRAWFORD, Proc. U. S. Nat. Mus. 38 (1910) 120.

"Closely resembles *Halictus*, but differs by the greatly elongate tongue, which is about as long as the antennæ, by having the inner spur of the hind tibiæ in the male armed with a few large teeth, and by having all the transverso-cubital veins, the cubitus beyond the second transverse cubital, and the upper two-thirds of the second recurrent vein, obsolescent." (*Crawford.*) This diagnosis was based on the male.

The female is larger (about 7.5 millimeters long), with the basitarsi piceous (they are ferruginous in the male); the hind spur has long spines. On account of the long linear tongue the genus is related to *Thrinchostoma*, but it differs in the structure of the hind legs, the absence of the hair patch on the wings of the male, and in other ways. The clypeus of the male is entirely black, flattened and shining in the middle.

### Nesohalictus robbii (Crawford).

*Halictus (Nesohalictus) robbii* CRAWFORD, Proc. U. S. Nat. Mus. 38 (1910) 120.

LUZON, Manila (*M. L. Robb and R. E. Brown*): Laguna Province, Mount Maquiling (*C. F. Baker*), Los Baños (*Baker*). PANAY, Antique Province, Culasi (*R. C. McGregor*), June, 1918; Maralison Island (*McGregor*), June 18, 1918. MINDANAO, Dapitan, Davao, and Cagayan (*Baker*). Another species of this genus, *Nesohalietus lativentris* (*Halictus lativentris* Friese), occurs in Java.

## Genus HALICTUS Latreille

The metallic species have been previously described, but one described below (*H. opisthochlorus*) is partly metallic. The

species of *Halictus* are ground-nesting bees of relatively feeble flight, and the wide distribution of several species through the islands of the Archipelago is rather surprising. The smaller species are sometimes referred to as sweat bees, from their habit of settling on the skin, apparently attracted by the perspiration. Is it perhaps possible that they occasionally attach themselves to birds, and thus get carried about? The following key should suffice for the separation of the species before me. I include *Nesohalictus*, as it is likely to be mixed with *Halictus*.

Males ........................................ 1.
Females ........................................ 8.

1. Clypeus with a yellow or whitish transverse apical band.................... 2.
   Clypeus entirely black........................................ 4.
2. Tibiæ yellow, with dark markings; scape with a light stripe; area of metathorax not plicate or only very delicately so near base.
   eschscholtzi sp. nov.
   Tibiæ mainly or wholly dark........................................ 3.
3. Flagellum ferruginous beneath; hind tarsi or, at least, basitarsi yellow.
   philippinensis Ashmead.
   Flagellum dark or dusky beneath; hind tarsi dark.
   philippinensis nigritarsellus var. nov.
4. Mesothorax dull or dullish........................................ 5.
   Mesothorax shining........................................ 6.
5. Larger; stigma pale ferruginous; tarsi light red.
   Nesohalictus robbii Crawford.
   Smaller; stigma dark brown; tarsi dark.................... melanurops sp. nov.
6. Head very large; scape largely red; anterior knees red.... scapalis sp. nov.
   Head not unusually large........................................ 6a.

6a. Very small species; mesothorax highly polished, without conspicuous punctures ........................................ lionotulus sp. nov.
   Small species; mesothorax shining, but finely and distinctly punctured.
   itaminus sp. nov.
   Larger; mesothorax with evident punctures........................................ 7.

7. Mesothorax coarsely punctured; first abdominal segment closely punctured all over........................................ baguionis Crawford.
   Mesothorax polished, more finely punctured; first abdominal segment without evident punctures........................................ luzonicus Strand.
8. Tibiæ mainly yellow or reddish yellow; tubercles yellow.
   eschscholtzi sp. nov.
   Tibiæ and tubercles not thus yellow........................................ 9.
9. Mesothorax dull, without evident sculpture........................................10.
   Mesothorax more or less shining or evidently sculptured........................12.
10. Metathorax dark green (Baguio)........................... opisthochlorus sp. nov.
    Metathorax black, the area granular, without evident sculpture .......11.
11. Apical part of metathoracic area shining and with a median groove (Puerto Princesa)........................................ caroli sp. nov.
    Apical part of area entirely dull; larger species (Culasi and Mount Maquiling) ........................................ mcgregori sp. nov.

12. Area of metathorax entirely dull, very coarsely reticulate.
thoracicus sublustrans subsp. nov.
Area of metathorax shining or closely sculptured....13.
13. Large species, with dark tegulæ and very coarsely punctured mesothorax; apical area of first abdominal segment closely punctured.
baguionis Crawford.
Mesothorax not thus coarsely punctured.... 14.
14. Scutellum sparsely punctured....15.
Scutellum closely or finely punctured, often dullish or dull....22.
15. Scutellum dullish, with large, very sparse punctures; mesothorax dull, with large sparse punctures (Mount Banahao)... oligostictus sp. nov.
Scutellum shining; mesothorax with fine or close punctures....16.
16. Mesothorax highly polished, little punctured; tegulæ amber....17.
Mesothorax dull or distinctly punctured....18.
17. Hind margins of abdominal segments testaceous; area of metathorax distinctly striate, except the shining apical part (Mount Maquiling).
lionotulus sp. nov.
Hind margins of abdominal segments not testaceous; area of metathorax not distinctly sculptured (Mount Banahao).
scintillans sp. nov.
18. Head very large; scape largely red; anterior knees red in male; female unknown (Mount Banahao).... scintillans sp. nov.
Head not large; scape dark; abdomen with distinct bands of tomentum at bases of at least some of the segments....19.
19. Larger species; middle of hind basitarsi with ferruginous hair on inner side; mesothorax shining and with very distinct punctures.
luzonicus Strand.
Smaller species; basitarsi without strongly red or orange hair....20.
20. Stigma pale testaceous; area of metathorax shining, with very distinct longitudinal plicæ; first abdominal segment with a tuft of white hair on each side.... philippinensis Ashmead.
Stigma dark....21.
21. Disk of mesothorax very sparsely punctured; posterior truncation of metathorax brilliantly shining (Baguio).... postlucens sp. nov.
Disk of mesothorax much more closely punctured; posterior truncation dull or dullish, except upper end.... itaminus sp. nov.
22. Hind margins of at least some of the abdominal segments pale testaceous; tegulæ rufotestaceous; stigma dull reddish, not dark....23.
Hind margins of abdominal segments not testaceous....25.
23. Testaceous band on second abdominal segment in middle occupying about half of segment; first segment with broad testaceous margin; hind tibiæ and tarsi dull reddish (Mount Maquiling).
fulvovittatus sp. nov.
Testaceous band on second abdominal segment, if present, not occupying a fourth of segment.... 24.
24. Larger; truncation of metathorax distinctly margined above (Davao).
davaonis sp. nov.
Smaller; truncation not bounded above.... nesiotus Crawford.
Like the last, but more robust, with red knees and redder tegulæ.
nesiotus domitus var. nov.

25. Second abdominal segment wholly without basal band or patches of tomentum; mesothorax dull; punctures of scutellum very irregular; area of metathorax dullish, with strong plicæ (Mount Banahao and Imugan) ........................................ melanurops sp. nov.
Second abdominal segment with basal band or lateral patches of tomentum ........................................ 26.
26. First recurrent nervure meeting second transverse cubital; tongue linear.
Nesohalictus robbii (Crawford).
First recurrent nervure joining second submarginal cell; mouth parts ordinary for the genus; hair of postscutellum light fulvous.
banahaonis Cockerell.

Halictus itaminus sp. nov.

*Female.*—Length, about 6 millimeters; black, with thin white hair, conspicuous on sides of thorax and forming a dense tomentum on postscutellum; head normal, face broad but eyes strongly converging below, clypeus somewhat produced; mandibles black, reddish at end; underside of head flattened, finely and densely striate; antennæ dark, the flagellum faintly brownish beneath; front dull, extremely densely punctured; clypeus irregularly punctured; mesothorax shining but not highly polished, the punctures distinct and well separated, the median groove well developed; scutellum convex, shining, sparsely punctured, with no median groove (*H. gedensis* has it dullish, with a median groove); area of metathorax appearing roughened (but under microscope seen to be reticulated) at middle and base, the posterior part at side being smooth (microscopically tessellate), while the posterior middle is somewhat swollen, with a median depression; posterior truncation dull except upper part, which is shining, its sides angular; sides of thorax dull, except a shining area below the wings; tegulæ piceous; wings dusky, stigma (which is large) and nervures piceous; first recurrent nervure meeting second transverse cubital; legs black, with pale hair; hind spur with long spines; abdomen shining, with white hair bands, broadest laterally (not always clearly visible) at bases of second and third segments; venter with white hair.

*Male.*—Very much like the female, but smaller and slenderer; clypeus entirely black; legs entirely dark; mesothorax shining.

LUZON, Laguna Province, Mount Maquiling, 10 females and 8 males (the type is a female); Mount Banahao, 1 female: Mountain Province, Baguio, 1 female. All from Baker.

This is very close to certain species of Java, *H. gedehensis* Friese and especially *H. gedensis* Ckll., differing from the latter especially in the scutellum, as is indicated in the preceding description.

**Halictus nesiotus** Crawford.

*Halictus nesiotus* CRAWFORD, Proc. Ent. Soc. Washington 19 (1918) 169.

LUZON, Mountain Province, Baguio (*Wirt Robinson*), type locality: Laguna Province, Mount Maquiling (*Baker*), 4 females; Mount Banahao (*Baker*), 1 female. I have not seen Crawford's type, but he has kindly confirmed my identification from a specimen sent to him.

**Halictus nesiotus** var. **domitus** var. nov.

Another specimen from Mount Banahao is more robust, with red knees, bright ferruginous tegulæ, and third and fourth abdominal segments (but not first and second) rather broadly margined with testaceous. It may be a distinct species, but for the present it may stand as a variety.

**Halictus baguionis** Crawford.

*Halictus baguionis* CRAWFORD, Proc. Ent. Soc. Washington 19 (1918) 170.

LUZON, Mountain Province, Baguio (*Robinson, Baker*): Mount Banahao (*Baker*): Nueva Vizcaya Province, Imugan (*Baker*).

This species appears to be abundant at Baguio, but a few specimens have been seen from other localities. I have one of Crawford's cotypes.

**Halictus luzonicus** Strand.

*Halictus luzonicus* STRAND, Berl. Ent. Zeitschrift 54 (1909) 208.
? *Halictus manilæ* ASHMEAD, Canad. Ent. 36 (1904) 281.
*Halictus manilæ* COCKERELL, Proc. U. S. Nat. Mus. 36 (1909) 420; CRAWFORD, Proc. Ent. Soc. Washington 19 (1918) 169, 170.

Strand's type was from Luzon (*Jagor*); Ashmead's, from Manila (*Stanton*). Ashmead's type, preserved in the United States National Museum, is the same as *H. luzonicus;* but Ashmead's description states that the insect, a female, is only 6 millimeters long, and the head from the base of the antennæ upward is greenish metallic. It appears probable that Ashmead began his description with one thing and finished with another, accidentally picking up the wrong specimen. At all events, I know of no species agreeing with his description and prefer to use the name *luzonicus,* which is supported by a full and accurate account of the characters.

LUZON, Mountain Province, Baguio (*Robinson, Baker*): Laguna Province, Los Baños (*Baker*); Mount Maquiling (*Baker*):

Nueva Viscaya Province, Imugan (*Baker*). It appears to be abundant at Baguio, but is represented by a few specimens from the other localities.

Halictus philippinensis Ashmead.

*Halictus philippinensis* ASHMEAD, Proc. U. S. Nat. Mus. 28 (1904) 128; COCKERELL, Proc. U. S. Nat. Mus. 36 (1909) 419; CRAWFORD, Proc. Ent. Soc. Washington 19 (1918) 169, 170.

LUZON, Manila (*Stanton*): Laguna Province, Los Baños (*Baker*); Mount Maquiling (*Baker*): Mountain Province, Baguio (*Baker*): Tayabas Province, Malinao (*Baker*). LEYTE, Tacloban (*Baker*). PANAY, Antique Province, Culasi (*McGregor*), June, 1918. NEGROS, Cuernos Mountains (*Baker*). MINDANAO, Davao (*Baker*); Cagayan (*Baker*); Zamboanga (*Baker*). BASILAN (*Baker*). PALAWAN, Puerto Princesa (*Baker*).

This is the commonest and most widespread *Halictus* in the Archipelago, extending from Luzon to Mindanao and Palawan, A specimen from Los Baños carries a manuscript name given by Friese.

Halictus philippinensis var. nigritarsellus var. nov.

*Male*.—Hind tarsi dark; flagellum dark or dusky beneath. The tarsi are entirely without yellow, but the last joint is ferruginous apically. Type of the variety from Pagsanhan, Laguna Province; others from Mount Maquiling and Los Baños, Luzon. All from Baker.

Halictus thoracicus sublustrans subsp. nov.

*Female*.—Length, about 6 millimeters; similar to *H. thoracicus* Friese, from Java, but with the abdomen shining and tegulæ, stigma, and nervures piceous or black. The dense tomentum on the postscutellum is white, often with a delicate ocherous tint. The species is very peculiar for the wholly dull area of the metathorax, with large reticulations, and especially for the sculpture of the mesothorax, which appears rough under a lens but under the microscope is seen to have a raised network or cancellation all over, entirely different from the fine tessellation often seen on the thorax of bees.

LUZON, Nueva Viscaya Province, Imugan (*Baker*), 5 (including the type): Mount Banahao (*Baker*), 2. PANAY, Antique Province, Culasi (*McGregor*), 3, at flowers of *Homalanthus populneus* Pax, June 3, 1918.

Halictus thoracicus var. merescens var. nov.

*Female*—Tegulæ rufous or rufotestaceous, sometimes darker; stigma reddish brown to dark brown.

LUZON, Mount Banahao (*Baker*) 7; Los Baños (type locality of variety) (*Baker*), 3; Mount Maquiling (*Baker*), 5. PANAY, Antique Province, Culasi (*McGregor*), 1, at flowers of *Homalanthus populneus* Pax, June 3, 1918. LEYTE, Tacloban (*Baker*), 1. MINDANAO, Davao (*Baker*), 1.

I have seen true *H. thoracicus* Friese from Buitenzorg, Java (*Bryant and Palmer*).

Halictus banahaonis Cockerell.

*Halictus banahaonis* COCKERELL, Ann. & Mag. Nat. Hist. VIII 14 (1914) 365; 15 (1915) 264; CRAWFORD, Proc. Ent. Soc. Washington 19 (1918) 169.

LUZON, Mount Banahao (*Baker*), 4; Paete (*Baker*), 1.

The hind margin of the first abdominal segment is lineolate, not punctured all over as in *baguionis* Crawford, contrary to the statement in Crawford's table, loc. cit.

Halictus banahaonis var. macerula var. nov.

*Female*.—Smaller; anterior wing, about 5 millimeters long (about 6 millimeters in type); length of insect, 6 to 6.5 millimeters.

LUZON, Mount Banahao (*Baker*), 18. The difference of size and bulk is very conspicuous, and the two lots are uniform. Presumably the two forms are adapted to different flowers. The type of the variety is *Baker 2556*.

Halictus eschscholtzi sp. nov.

*Halictus manilæ* STRAND (not of Ashmead), Berl. Ent. Zeitschrift 54 (1909) 210; CRAWFORD, Proc. Ent. Soc. Washington 19 (1918) 169.

*Female* (*type*).—Length, about 7 to nearly 9 millimeters; black, with the tubercles yellow; mandibles bright chestnut red, except at base; knees, tibiæ, and tarsi reddish yellow, or the anterior tibiæ light red with a yellow stripe, the middle and hind tibiæ and hind basitarsi each with a large dusky area; flagellum red beneath, and scape with a red basal spot; hair of head and thorax ochraceous, abundant on thorax, forming a fine down on mesothorax, conspicuous in certain lights, not in others, but sides of mesothorax with dense bands of tomentum, posteriorly extending narrowly in front of scutellum; mesothorax dull, it and the scutellum very minutely rugosely

punctate; area of metathorax rather large, dull, microscopically rugose, with a slight tendency to plication basally; tegulæ testaceous, with a yellow spot; wings hyaline, with pale ferruginous stigma and nervures; first recurrent nervure joining second submarginal cell some distance before its end; third submarginal cell much broader in middle than second; outer recurrent and transverse cubital weakened; posterior face of metathorax densely covered with hair; legs with pale ocherous hair; hind spur with four long slender spines and a fifth rounded rudiment; abdomen broad, moderately shining, with a sericeous surface; basal part of first segment with dense pale ocherous hair, and segments 2 to 4 with dense basal bands; ventral segments polished and shining basally.

*Male.*—Length, about 6.5 millimeters; clypeus with a broad yellow apical band; labrum yellow; mandibles broadly yellow in middle, but with a black spot at base; scape yellow in front; flagellum rather long; dark areas on tibiæ smaller, and hind basitarsi all yellow; hind margins of abdominal segments very narrowly fulvous; apical plate very broad and rounded; third ventral segment with a dense stiff brush of whitish hair along the margin, not reaching the sides.

LUZON, Laguna Province, Los Baños (*Baker*), type locality; Mount Maquiling (*Baker*); Pagsanhan (*Baker*), the male described and 2 females: Manila (*Eschscholtz*), type of *H. manilæ* Strand. MINDANAO, Cagayan (*Baker*); Dapitan (*Baker*).

A male from Mount Maquiling is *Baker 2560.* A very distinct species, on account of the color of the legs resembling *H. roepkei* Friese, from Java.

Halictus opisthochlorus sp. nov.

*Female.*—Length, nearly 7 millimeters; anterior wing, 4.75 millimeters; black, with the upper part of the metathorax dark blue-green; pubescence scanty, face with inconspicuous dark fuscous hairs, mesothorax almost bare, sides of thorax with thin white hair, abdomen without hair bands or patches, but with a scopa of long, white, curled hairs on ventral surface; head broad and short; antennæ black, scape reaching to level of ocelli; face and front dullish with a sericeous luster; mesothorax and scutellum dullish, with a sericeous luster and without evident punctures; area of metathorax with very fine striæ, appearing granular under a lens; posterior truncation not sharply defined; tegulæ brownish black; wings dusky hyaline, strongly iridescent; stigma and nervures piceous; second and

third submarginal cells about the same size, high and narrow, together smaller than first; first recurrent nervure meeting first transverse cubital; legs black, inner side of hind tarsi with bright ferruginous hair; hind spur pectinate; abdomen shining black, without evident punctures. The abdomen is like that of *H. melanurops*.

LUZON, Mountain Province, Baguio (*Baker*). This species and the next two show a general relationship to some of the Australian forms. On the other hand, *H. baguionis* Crawf. is related to the Formosan *H. perangulatus* Ckll.; so we have in the Philippines a meeting place of northern and southern groups of the genus.

**Halictus caroli** sp. nov.

*Female.*—Length, 6 millimeters; black, with broad abdomen; hair of head and thorax white, abundant at sides of thorax and long on clypeus; antennæ black, with basal half of scape red in front; inner orbits rather strongly concave; face and front dullish; mesothorax and scutellum dull, without evident punctures; area of metathorax dull and granular, a little shining at apex, where there is a median sulcus; tegulæ pale testaceous; wings faintly dusky, nervures and stigma piceous; second and third sumarginal cells high and narrow, about equal; first recurrent nervure joining second submarginal cell near end; legs black, small joints of tarsi ferruginous; abdomen black, shining, without bands or patches of tomentum; venter with a scopa of long curled hairs, tinged with ocherous at sides.

PALAWAN, Puerto Princesa; sent by Prof. C. F. Baker, after whom it is named.

**Halictus mcgregori** sp. nov.

*Female.*—Length, 7 millimeters; black, with broad abdomen; hair of head and thorax scanty, but dense and dull white on tubercles, and sides of metathorax with a conspicuous white fringe; head broad, clypeus short; antennæ black; supraclypeal area strongly convex; face and front moderately shining; mesothorax and scutellum dull, without evident punctures; area of metathorax large, entirely opaque, faintly striate at sides toward base; posterior truncation hairy; tegulæ ferruginous; wings dusky, nervures and stigma piceous; second and third submarginal cells high and narrow; first recurrent nervure meeting second transverse cubital; legs black, hind tibiæ and tarsi with black hair on outer side and fulvous on inner; hind spur with a few large teeth; abdomen dullish, without band or

patches of tomentum; venter with a scopa of long curled hairs and large patches of pale fulvous hair at sides of segments.

PANAY, Antique Province, Culasi (*McGregor*), type, June 3, 1918. LUZON, Laguna Province, Mount Maquiling (*Baker*), 1.

Halictus oligostictus sp. nov.

*Female.*—Length, nearly 8 millimeters; very robust; black, pubescence scanty, fringe of tubercles dense and tinged with ocherous; antennæ black, the flagellum faintly reddish apically; clypeus with large punctures; front dullish, finely punctured and substriate; mesothorax and scutellum dull, with large, widely scattered punctures, very few on scutellum; area of metathorax dull, with strong longitudinal plicæ; posterior truncation finely tomentose, sharply defined above and at sides; prothorax with prominent tubercular and anterolateral angles; tegulæ black; wings slightly dusky, stigma and nervures piceous; first recurrent nervure meeting second transverse cubital; third submarginal cell more than twice as long (broad) as second; legs black; hind tibiæ and tarsi with black hair on outer side and pale yellowish hair on inner; hind spur with a few large spines; abdomen very broad, shining black, without evident punctures; second segment with a narrow patch of dull white tomentum on each side basally; venter with pale hair, but no long curled scopa or lateral patches.

LUZON, Mount Banahao (*Baker*).

Halictus lionotulus sp. nov.

*Female.*—Length, about 5.5 millimeters; black, with rather narrow thorax; hair of head and thorax dull white, not abundant; face narrowed below; clypeus and supraclypeal area shining, sides of face with dense grayish white hair; flagellum obscurely brown beneath; mesothorax and scutellum polished and shining, without conspicuous punctures; area of metathorax dull, with fine plicæ, the rounded apical margin shining; posterior truncation very hairy; tegulæ bright fulvous; wings dusky, stigma and nervures dusky reddish brown, not dark; outer recurrent and transverse cubitals much weakened; type with only two submarginal cells, the second transverse cubital absent, but another female, evidently of the same species, has three submarginals, the third broader than the second, but not twice as broad (the male also has three submarginals); legs black or dark brown, with much white hair, that on hind tibiæ entirely white; hind basitarsi with white hair, but with an orange brush at apex; mesopleura polished and shining; abdomen

shining, without evident punctures, hind margins of segments rather narrowly hyaline; the cotype (but not the type) shows some pale tomentum at extreme bases of second and third segments; fifth segment covered with white hair; venter with stiff white hair, but no curled scopa or lateral patches.

*Male.*—Length, about 5 millimeters; slenderer, flagellum not elongated, clypeus all black.

LUZON, Mount Maquiling (*Baker*), 2 females and 1 male. The type is a female.

Halictus scintillans sp. nov.

*Female.*—Length, about 6 millimeters; like *H. lionotulus*, but larger, with the hind margins of the abdominal segments not hyaline, and the area of the metathorax without distinct striæ, except at the extreme base, where they are very delicate.

LUZON, Mount Banahao (*Baker*), 1. It is quite likely that additional material will prove this to be only a local race or variety of *H. lionotulus*.

Halictus scapalis sp. nov.

*Male.*—Length, about 8 millimeters; black, robust, having the general form and superficial appearance of *H. oligostictus*; head very large, face extremely broad; cheeks very broad; mandibles ferruginous, black at base and apex; face and front glistening, with short pale ocherous hair; labrum chestnut red, with a pair of prominent projecting tubercles; clypeus closely punctured, with a median smooth raised band; scape slender and curved, basal half red; a groove running between the posterior ocelli; mesothorax and scutellum polished and shining, the mesothorax with rather close delicate punctures, the scutellum very sparsely punctured; area of metathorax well defined, shining, its basal half with strong regular plicæ; thorax with pale ocherous hair; mesopleura dullish, finely lineolate; tegulæ reddish; wings slightly dusky; stigma rather small, dark reddish, nervures brown; first recurrent nervure joining second submarginal cell before its end; third submarginal cell very broad, much larger than second; outer nervures distinct; legs dark brown or nearly black, with pale ocherous hair, anterior knees red, tarsi ferruginous apically; abdomen broad, shining, first segment without evident punctures, second finely punctured; pale tomentum at sides of base of segments 2 to 4; apical plate reddish, very broad and rounded. Flagellum short and abdomen broad as in females.

LUZON, Mount Banaho (*Baker*). A remarkable species.

**Halictus postlucens** sp. nov.

*Female*.—Length, about 7 millimeters; black, with pale ocherous hair; head ordinary; face glistening, clypeus with a depression at apical middle; front dull, narrowly shining along orbits; antennæ black; scutellum with fuscous hair, postscutellum with pale tomentum; mesothorax and scutellum shining, sparsely and finely punctured; area of metathorax poorly defined, glistening, with feeble, raised lines, and apically distinct traces of transverse striæ; posterior truncation well defined, smooth and shining; tegulæ piceous, with a reddish spot; wings dusky, stigma and nervures dull reddish, not dark; first recurrent nervure joining basal corner of third submarginal cell; third submarginal cell considerably larger and broader than second, though second is fairly broad; legs black, with pale ocherous hair, tarsi reddened at apex; abdomen shining, without evident punctures; some pale tomentum at bases of second and following segments; venter with pale ocherous hair, not forming a long curled scopa or lateral patches.

LUZON, Mountain Province, Baguio (*Baker*).

**Halictus fulvovittatus** sp. nov.

*Female*.—Length, 6 to 6.3 millimeters; black, the hind margins of the abdominal segments broadly testaceous or pale golden, the bands shading into ferruginous along their anterior margins, the bands on first two segments broader in the middle than at the sides; hair of head and thorax white with a creamy tint, dense on upper border of prothorax laterally, on margins of tubercles, and on postscutellum, thin on face; head ordinary; mandibles dark red in middle; flagellum obscurely reddish beneath; middle of clypeus depressed and punctured; a shining line along anterior orbits; mesothorax and scutellum finely and rather closely punctured; area of metathorax finely but very distinctly striate on basal half; posterior truncation with long hair and without sharp margins; tegulæ bright fulvous; wings faintly dusky, nervures and stigma dilute reddish sepia; first recurrent nervure joining second submarginal cell near apex; third submarginal cell larger than second, but higher than broad; knees and small joints of tarsi ferruginous; hind tibiæ and tarsi dull reddish; hind spur with three stout teeth; abdomen broad, conspicuously thinly hairy, but without bands or patches of tomentum; venter with short hair, but no curled scopa or lateral patches.

LUZON, Laguna Province, Mount Maquiling (*Baker*), 2.

**Halictus davaonis** sp. nov.

*Female*.—Length, about 6.5 millimeters; black, differing from *H. fulvovittatus* thus: Head broader; area of metathorax with a double sculpture of exceedingly delicate striæ all over and coarse rugæ basally; legs black, with red knees; pale marginal tegumentary bands on abdomen much narrower, those on first two segments not enlarged in middle.

MINDANAO, Davao (*Baker*), 2. Closely related to the last, but surely a distinct species.

**Halictus melanurops** sp. nov.

*Female*.—Length, about 7 millimeters; black, with little hair; abdomen polished and shining, without bands or patches of tomentum; head broad; clypeus dull basally, apically shining and with large punctures; supraclypeal area dull; front dull, densely punctured; sides of vertex closely punctured; antennæ black; cheeks striate, with a large polished shining space on lower part; mesothorax and scutellum dullish, finely punctured, the punctures very irregular on scutellum; area of metathorax longitudinally plicate; posterior truncation shining, not sharply bounded at sides; mesopleura dull; tegulæ black; wings dusky, stigma and nervures brown; first recurrent nervure meeting second transverse cubital; third submarginal cell not much larger than second, both rather broad; legs black; hind tibiæ with fuscous hair on outer side and white hair on inner, hair on inner side of hind basitarsi white; abdomen with stiff hair on venter, but no curled scopa or lateral patches; along the apical margin of the covered portion on dorsal segments 2 to 4 is a very fine fringe of plumose white hairs, forming a very delicate line.

*Male*.—Very similar but smaller; clypeus all black; flagellum elongated and submoniliform, as in typical *Halictus* males; tarsi dark.

LUZON, Mount Banahao (*Baker*), 1 female, type: Nueva Vizcaya Province, Imugan (*Baker*), 1 female: Mountain Province, Baguio (*Baker*), 1 male.

# THE SWARMING OF ANOPHELINE MOSQUITOES [1]

By Charles S. Banks

*Professor of Entomology, University of the Philippines*

The swarming of Culicidæ has been reported from all parts of the world where these insects are found. Almost every record of such swarming has to do with members of the subfamily Culicinæ, as far as it is possible to ascertain. W. W. Smith says [2] that in New Zealand "a train passed through a wall of mosquitoes three quarters of a mile in length, twenty feet high and eighteen inches thick" and that this swarm was composed of *Culex* (*Uranotænia*) *argyropus* Walk. J. W. Douglas reports [3] a similar occurrence in London, where for ten days hordes of members of the genus *Culex* swarmed over the neighborhood and appeared like smoke when it issues from chimneys. They rose in the air for 10 meters and continually danced up and down in the twilight stillness. Holiday [4] records a like phenomenon in which *Culicada nemorosa* Meig. (synonym *Culex detritus*) was the species. F. V. Theobald [5] gives an account of *Culex pipiens* L. on the Downs, near Wye, England, "dancing in little clouds where they were sheltered from the wind." Romolo Gessi Pascha [6] speaks of myriads of mosquitoes, which obscured the air at Meshra-el-Rek.

Accounts similar to these have come from every Arctic explorer; and persons who have returned from Juneau, Nome, and Skagway, as well as other parts of Alaska, and from northern Siberia including Kamchatka Peninsula, even north of the Arctic Circle, mention the immense swarms of mosquitoes that are to be encountered. It would seem from the reports that many of the swarms there were made up largely of females, which accords with my observations in northern New York in years gone by. The consensus seems to be that the swarms

[1] From the entomological laboratory, College of Agriculture, University of the Philippines, Los Baños.

[2] Ent. Mo. Mag. (1890) 321.

[3] Ibid. (1895) 239.

[4] The Entomologist 1 (1883) 151.

[5] Monograph of the Culicidæ of the World 1 (1901) 73.

[6] Seven Years in the Soudan (1892) 47.

seen in the warmer parts of the earth are largely composed of males.

No mention seems to have been made, in accounts dealing with mosquito swarming, of Anophelines performing this interesting act. Two years ago this month (in March, 1917) having had occasion to descend Faculty Hill at the college campus, at dusk, I encountered two or three distinct swarms of *Myzomyia rossii* Giles dancing in the air, at a height of about 2.5 meters above the roadway. Rapidly sweeping my hand through the swarm I caught a few specimens for the purpose of identification, as I did not observe at the time that they were Anophelines, not Culicines. A note of the occurrence was made, but no further observations were had and the matter was forgotten until March 4 of this year (1919) when, upon returning home from my laboratory at 6.25 in the evening I encountered four distinct swarms within 60 meters of my house, which stands on a rise of ground at the foot of Faculty Hill. These swarms were hovering at about 1.5 meters above the roadway; their music was quite audible, and they were flying against a wind having a velocity of 12 to 15 kilometers an hour, maintaining themselves without the slightest difficulty at any point desired (as, for instance, directly overhead) and following me as I passed through the swarm.

When my hand swept among them, in order to capture a few, the whole mass darted off to right or left, or up or down the road, with the greatest ease and with a decidedly concerted motion, returning when the disturbance ceased. Hastening to the house, I secured a net and returned to find that they were even closer to the ground than before, the base of the swarm being less than a meter from the roadway; but, as the entire swarm was dancing up and down, the individuals frequently rose to a height of 3 to 4 meters in the air.

With a couple of sweeps of the net, I caught one hundred twenty-seven individuals out of two of the swarms and I estimated that each swarm must have contained in the neighborhood of a thousand individuals.

On the evening of March 5 the same phenomenon was witnessed about 100 meters farther up the same road, at precisely the same hour. The road at this point was well shaded on both sides by several high trees. The swarms in this case were very much larger than those seen the previous evening. They extended higher into the air and seemed to dance with much more

vigor, the wind at that time blowing at only about 9 to 10 kilometers an hour. Out of these swarms seven hundred ninety-four mosquitoes were captured, all males, though sweeps were made at the edges of the swarms in the hope that females might be lurking on the outskirts. As night fell very rapidly, it was impossible on either of these occasions to ascertain the presence of females by observing a different character of flight between the two sexes.

It should be noted here that on the evening of the fifth a great number of females of this species was taken in the house at light, and they were also found in considerable abundance clustering and flying close to the nipa roof of the veranda, a favorite hiding place for Anophelines and a place where thousands of them must be captured nightly by a certain little spider, the habits of which are to be described elsewhere.

Further observations, made on the evening of March 6 at the same hour, revealed other interesting and important features of this swarming of Anophelines. Having stationed myself at 6.15 in the evening, at the upper part of the road nearly opposite the Forestry Station, I noticed some half dozen males of *M. rossii* flying swiftly up and down the road, about 1.5 meters above it. Within five minutes several hundreds had assembled, and within five minutes more there were many thousands, grouped roughly into three distinct clusters about 8 to 10 meters apart, each cluster connected with the others by numerous stragglers. Selecting a favorable spot, which would place the swarms between me and the sky, which was then of a pinkish blue, I waited to see what would occur.

At 6.30 the first female was seen to be caught by a male, and the pair flew slowly and obliquely upward and away from the swarm and was soon lost to sight. At intervals of about fifteen seconds other females were observed and this continued until 6.40; so that approximately fifty females were seen to enter the swarm and to be seized by males, each time the pair flying slowly but directly out of the swarm. Two pairs were seen to separate after about thirty seconds in copulation. At 6.45 the swarms had diminished more than half and at 6.50 only a few stragglers could be seen against the rapidly darkening sky.

Whether the mosquitoes came from the thick undergrowth at both sides of the road, as is probable, or whether they flew up or down the road, it is impossible to say; but the rapidity

of assembling and dispersing and the scant half hour during which the swarms were definite enough to be called such, might indicate a precise purpose and an exact time of the day for carrying out that purpose.

On this afternoon a very mild breeze was blowing, but there were occasional gusts which seemed to stimulate the mosquitoes to greater activity and to cause them to bunch together with a very quick movement, as players in a foot-ball scrimmage. If I stood perfectly still beneath a swarm, it came close to my head; if, on the other hand, I even gently thrust my hand upward, the Anophelines rose en masse away from it.

During the whole time of swarming, two dragon flies were darting in and out of the swarms, and each quite obviously caught a mosquito every time.

The two remarkable features of these occurrences are that the insects are Anophelines, and that they were swarming during a very stiff breeze on each occasion. Many observers, entomologists as well as non-entomologists, have maintained that high winds are inimical to the welfare of the mosquito, and that the insects will not venture forth when strong winds are blowing. It has been repeatedly stated that when mosquitoes are found at a distance from water, they have been wafted thither by gentle breezes. G. M. Giles, says:[7]

* * * as naturalists are generally agreed that gnats cannot travel to any considerable distance, it follows that food both for adult and larva must be obtained within a limited area, for mosquitoes cannot and do not fly far. It is impossible to fix any absolute limit to their powers in this respect, but it may be safely asserted that few individuals ever stray much more than a quarter of a mile from the pool in which their larval youth was passed, and the great majority never travel further than the nearest shady spot. Nor, in spite of popular beliefs to the contrary, can they be carried far by the wind. Mosquitoes, indeed, exhibit a well-founded, instinctive dread of boisterous weather, and will not leave shelter in a high wind. Those accidentally carried away are, I am inclined to think, rapidly disabled.

Another reason that makes it impossible for Mosquitoes to be carried overseas any considerable distance by the wind is that, whatever may be the rate of travel that they can bear without injury, the entire journey must be made at night, for in tropical regions shelter from the sun during the day is a matter of life and death to a Mosquito * * *.

For these reasons, we may, I think reject, as having no foundation in fact, such popular beliefs as that the swarms of Mosquitoes that sometimes appear on the Persian coast, have been carried by the wind 200 miles across the Gulf from the Arabian shore; albeit you must be prepared to hear this belief quoted as an established fact, even by European residents.

[7] Gnats or Mosquitoes, ed. 2. London (1902) 112, 113.

I feel very safe in asserting that, from the observations made upon these anopheline mosquitoes in their action of flying against a stiff wind, we must certainly conclude that they have much greater power of flight than would be inferred from their apparently frail structure. If it be true that this species is so resistant to the wind—or rather, so capable of maintaining itself in safety in a high wind—what may not be expected of the more robust Culicines, such as *Culex fatigans* Wied., *Mansonia uniformis* Theob., *Stegomyia scutellaris* Walk., and one or two other species, the occurrence of which in a given locality can only be explained by the fact that they must have "come upon the wind?" If Anophelines, naturally more delicate in structure and with narrower wings and slenderer legs than those mentioned above, can fly against a 12-kilometer wind and maintain themselves at a given point, how much more easily could they or other mosquitoes be carried along by a wind, in which case they would simply be required to "give way" to its force and keep their balance!

The ready ease with which these insects evade the captor's hands and even his net would indicate that they possess in a very keen degree the percussion sense, that this would materially aid them in their windborne journeys in avoiding obstacles such as trees, and that they would find little or no incovenience in being wafted through wooded areas or around houses and other similar objects.

The ability to fly against the wind, together with their sense of smell, would make it possible for them at any time in their journey to "drop out" of the wind current in which they might be carried, and attack any animal or enter any house in their path. This is always on the assumption that females as well as males are at times addicted to the swarming habit, and that they too would manifest the same activities as those of the opposite sex. There is certainly nothing to refute such a hypothesis.

Many difficulties lie in the way of ascertaining precisely the minimum, or even optimum, distances which mosquitoes will fly; but it is certain that, at least in the Philippines, we must revise our ideas with respect to their being such frail creatures, not daring to venture forth except in a summer zephyr; and it is hoped that further observations along this line will enable us to say with greater certainty how far a mosquito can or will fly.

Molauin Creek, a rapid mountain stream, dividing the campus of the College of Agriculture, lies northwest by north of the point where the first swarms of Anopheline mosquitoes were seen. It is not more than 150 meters away, and is separated by a moderately thick grove containing many bamboos. The strong breeze mentioned is the daily tail end of the southeast monsoon of this time of the year in this locality; these facts might be adduced to show that neither the intervening woods nor the strong breezes would keep the mosquitoes from invading the college buildings as well as the houses higher up the hill, all of which lie to the windward of their breeding places.

Malaria is most prevalent in this locality during the dry season; the creek furnishes an ideal breeding place for *Myzomyia febrifera* Banks during the entire dry period, and the range of activities of this pernicious little mosquito would, if it have the same powers of flight as *M. rossii*, appear to be limited only by two factors, gamete carriers and the number of individuals exposed.

# TWO PHILIPPINE LEAF-MINING BUPRESTIDS, ONE BEING NEW [1]

By CHARLES S. BANKS

*Professor of Entomology, University of the Philippines*

THREE PLATES

Buprestidæ are metallic beetles the larvæ, or grubs, of which are called flat-headed, or hammer-headed, borers. They are usually wood borers, but Kellogg [2] states that the smaller species sometimes mine in leaves or live in galls. Comstock [3] says:

> In some of the smaller species the larvæ are cylindrical, and are furnished with three pairs of legs. These are leaf miners; and in the adult state the body is much shorter than in the more typical species.

It is true that the larvæ here under discussion are somewhat more cylindrical than is usual in this family, but there is absolutely no indication of legs, while the adults conform to the description given by Comstock. It may be that larvæ of Buprestidæ from other parts of the world are provided with legs, but Schiote [4] says of the buprestid larva "*pedes nulli,*" and his figures of the larva of *Trachys minuta* L. very strongly resemble those of this species, which is closely related.

The occurrence of these larvæ in leaf mines is so rare, however, that a note concerning two species may be of interest, especially as the insects attack a plant of some economic importance because of its use as an ornamental.

The two species under consideration are *Endelus bakeri* Kerrem.,[5] a small beetle not more than 4.5 millimeters in length and particularly noteworthy because of its prominent eyes, which are placed on conical, tubercular projections of the epicranium; and *E. calligraphus,* a new species.

[1] From the department of entomology, College of Agriculture, University of the Philippines, Los Baños.

[2] American Insects (American Nature Series) (1908) 266.

[3] Manual for the Study of Insects (1896) 549.

[4] De Metam. Eleuth. Obs., Naturh. Tidsskr. 6 (1876) 361, pl. 2, figs. 18–22.

[5] Philip. Journ. Sci. § D 9 (1914) 88.

### ENDELUS BAKERI KERREMANS

The larvæ of the first species were found by one of my students, Mr. F. Q. Otanes, in blotch mines, singly, on the leaves of the bird's-nest fern (*Asplenium nidus* L.) on January 27, 1918, and the adults emerged on February 25.

Since they were first brought to my attention I have succeeded in discovering all stages of the insect as well as the larvæ, the pupæ, and the adults of the parasites that attack them.

#### EGG

The egg is a very flat, broadly elliptical object, with obtusely rounded ends. It is 1.75 millimeters long and 1.09 millimeters wide, dark chestnut brown over its discal area and pale to white around its margins, which are slightly crenulate, the submarginal area having a crinkled or undulated surface preceded mediad by a series of broad, rectangular, radiate fascia more or less indistinct. Along the median line are four groups of black, imbricated, subspinose prominences and an area of brown striæ which, being in subparallel series, may represent the area of the micropyle (Plate I, fig. 6).

The egg is so firmly glued to the leaf that it remains long after the affected leaf has died and becomes completely desiccated, and it serves as an excellent index to the beginning of a mine, where the battered condition of the leaf might make its discovery otherwise difficult. It is almost invariably laid on the lower surface of the leaf (Plate III, fig. 1) although it has been found on the upper surface of leaves near the center of the plant or where very little space intervenes between successive leaves (Plate III, fig. 2).

#### LARVA

Length, 7.5 millimeters; greatest width, 1.8 millimeters; thickness, 0.9 to 1 millimeter. It is pale apple green, the head being ochraceous or pale buff and this color dilutes the pale green of prothorax and mesothorax. The anal segment is almost white, slightly tinged with buff. The body is shiny and very translucent, so that the body fats and internal organs are plainly visible. The head when at rest is retracted for four-fifths its length into the broad, lobate prothorax, and is regularly cordate in outline, with a very narrow, dark brown line around its anterior half. The frontal suture is dark, well defined, and bifurcate caudad. The trophi are ferruginous, the antennæ short, stout and pale, with a stout, blunt terminal spine mediad and a slender seta, eight times as long, ectad (Plate II, fig. 3).

The prothorax has the laterocephalic lobes strongly, roundly produced cephalad, their anterior margins being on a line with the tip of the mouth or a little beyond. Its integument is finely reticulate-punctate and its lateral and cephalic margins are sparsely white haired, especially the lobes.

The mesothorax is two-thirds the length of the prothorax and is minutely punctate, these two segments being consequently dull glabrous. All the segments of the body caudad of the prothorax are strongly lobed laterad, except the twelfth, thirteenth, and fourteenth, the last being spherical; the other two, evenly rounded laterad; and the penultimate, five-eighths as wide as the antepenultimate.

The caudal margins of the first to the sixth abdominal segments are one-third to one-half longer than the cephalic margins; hence the lateral lobes are obcordate in outline (Plate II, fig. 3) and the segmental incisions are very deep. At the base of each lateral lobe on the dorsum is a convex, lunate, longitudinal sulcus which, with its neighbors, roughly outlines the lateral limit of the abdominal segmental articulations.

On the ventrum the second to the eighth abdominal segments are provided with sublateral, circular pseudopodal papillæ, laterad of which appear sulci, as dorsad, but somewhat more profound (Plate II, fig. 4).

In the last instar and previous to cessation of feeding, the larva measures 10 millimeters in length and is more buff or very dark cream, darker on the thoracic segments. The scutum and sternum of the prothorax are sharply outlined and darker and more chitinized than the surrounding integument. The anal segment is obtusely bilobed caudad. The abdominal pseudopodal papillæ are more prominent and glabrously corrugated.

The movements of the larva are very sluggish, both in the mine and when removed therefrom, and it has the peculiar habit of switching its tail from side to side in the gallery, thus leaving behind a fine string of excreta in a broad zigzag chain (Plate I, figs. 1, 2, and 3).

### PUPA

The pupa just after formation is 6 millimeters long and 2.25 millimeters wide, and is greenish cream-white, glabrous, and subcutaneously opaque. It follows very closely the general form of the adult except that its abdomen is narrower, with the segmental articulations constricted somewhat as in the

full-grown larva. It is quite devoid of hairs, cilia, spines, or roughened or chitinized areas of any kind. Its skin is microscopically shagreened.

### ADULT

The description of the adult is translated from Kerremans's original.

**Endelus bakeri** sp. nov.

Of the group of *E. weyersi* Rits. and *modiglianii* Kerrem. related on account of the head and prolongation of the ocular tubes [cones] to *E. diabolicus* Kerrem., but differing from that species by the elytral impressions and by the general coloration.

Short, pentagonal, entirely more or less bright bronze above; beneath almost black.

Head wide, deeply excavated; eyes protruding very much ectad, emerging from short truncated tubes [cones]; the surface almost glossy and very lustrous. Pronotum very much wider than long, short and stout, truncated cephalad with the anterior angles sharp and projecting, the sides widely arched cephalad and sinuous caudad with the posterior angles obtuse; the middle of the disc with two wide transverse carinæ. Scutellum small, triangular. Elytra short, stout, protruding at the shoulders, sinuous along their sides, attenuated caudad, individually widely rounded at their apices and minutely denticulated; the surface wavy and unequal, with wide lateral and discal impressions which are rounded, except those along the suture, on each side of the apex, which are elongated. Beneath smoother and more shiny than the elytra.

Length 3.5–4; width 1.25–1.5 mm.

LUZON, Los Baños.

These beautiful little purplish bronze beetles are especially noticeable by reason of the prominent, almost stalked eyes and the consequent excavation of the front of the head. The elytral undulations add to the brilliancy of the metallic color of which the legs, especially the femora, partake in a marked degree (Plate II, figs. 1, 5, 7, 10).

They remain for a certain period within the pupal skin after having apparently acquired all adult characters, including hardening and brilliancy of the integument, and for a somewhat shorter period in the mine. They fly rapidly, alighting after brief flights and running quickly over the leaf. Their copulation has not been observed nor has the egg-laying process been noted.

### MINES

The eggshell can always be found at the beginning of the mine, which for a distance of 12 to 15 millimeters is narrow, usually not over 2 millimeters in width, and follows the leaf veins. It may then turn at an obtuse angle, continue for 15

to 25 millimeters more, and spread out as a blotch covering nearly the entire space between midrib and margin (Plate I, fig. 2).

The tendency of the larva in mining is to proceed from the base to the apex of the leaf, but this is not the invariable course (Plate I, fig. 1). After it has made the main blotch mine, it invariably makes a second, very much smaller, chamber at a distance of from 10 to 15 millimeters, connected with the first by a gallery of an almost uniform width of 3 millimeters in nearly every instance. A third chamber may be made (Plate I, fig. 7), and even as many as four subsidiary chambers may be mined out by a single larva (Plate I, fig. 1) before it decides to pupate. It closes the entrance to this chamber by a lunate mass of compacted excrement (Plate I, figs. 2 and 3). Occasionally larvæ mining in opposite directions will cross each other's connecting galleries and continue in their determined direction.

The thin epidermis of the leaf soon dries and becomes torn, leaving very large, jagged, brown-bordered scars which detract from the beauty of this very ornamental plant.

### FEEDING HABITS OF THE ADULT

The adults of *Endelus bakeri* feed on the upper sides of the leaves in a very peculiar manner. They first eat out an oval space, devouring all of the upper epidermis and the parenchyma, leaving the lower epidermis entire. When this oval space is about the size of the body of the insect, instead of continuing to feed from outside the space, it deliberately settles down in the center of the denuded spot and proceeds with its meal from the bare white space. It is difficult to see why it should feed in this very strange manner, because its dark body is much more conspicuous against the white spot than against the darker green of the leaf.

It will be seen by reference to Plate III, fig. 2, that the white spots are located near the apex of the leaf; but this is not always the case, although the majority of them are found on the apical half of it. When a beetle is feeding it is not easily frightened from its repast and the hottest sunshine does not seem to annoy the insect.

### PARASITES

The larva of *Endelus bakeri* is parasitized by at least one species of chalcis fly, the female puncturing the epidermis of the leaf and laying her eggs through the dorsal skin of the

mesothoracic segment of the larva, leaving a black scar near its articulation with the prothorax. As many as eighteen punctures made by the ovipositor of the parasite were counted in the upper epidermis of a leaf over the fifth chamber of the larva. The larvæ of the parasite emerge from the pupa of the beetle and pupate around it, after the maner of many species of the Chalcididæ. The adults emerge through numerous circular punctures which they chew in the leaf epidermis. As many as twelve exuviæ of the parasite's pupæ have been counted around one beetle pupa carcass, and twelve adults were bred from one mine.

Adults of the parasite are tiny, metallic, purplish blue-green insects, with brownish black eyes and snow-white, black-tipped tarsi. The body is regularly ornamented with snow-white hairs, which are also found on the antennæ and legs. The length is about 1.25 millimeters.

It is believed that the larvæ are also attacked by a fungus disease, the disintegrated remains of several larvæ giving evidence of some such attack. Numerous mites of an undetermined species inhabit the leaf chamber, feeding on the débris left by the beetle larvæ.

### INJURY BY THE BEETLE AND REMEDY FOR ITS ATTACK

It is rare to find more than three larvæ in a single leaf, but each larva can do much toward injuring the leaves and thus spoiling the general appearance of the fern. The most expeditious method of combating the pest is to examine each leaf for the incipient mine and its occupant and, when located, simply to kill the larva by squeezing the spot between thumb and finger.

The seasonal prevalence of the beetle is not known; but, from the appearance of a large number of ferns examined at the college, it is believed they do most of their damage in the period from December to March. One of my students states that the insect was abundant in July and August of 1917.

In examining bird's-nest ferns for further specimens of the blotch mine buprestid, *Endelus bakeri*, my attention was attracted to a short-leaved plant, perhaps another variety of *Asplenium nidus*, in which the mines were linear and very tortuous, as shown in Plate I, fig. 4. Specimens of these leaves, containing nearly full-grown larvæ, were kept in cages, and to my great delight two adults emerged which are entirely different from *E. bakeri*. The specimens, both of which are fe-

males, prove to be a new species which I propose to call *Endelus calligraphus* from the great resemblance of the mines to handwriting.

Leaf specimens thus far examined show the eggs as being laid almost invariably near the tips, the larvæ working toward the petiole and then crossing and recrossing their older galleries, often returning as close to the leaf tip as possible, but always going back down the midrib for pupation in a very slightly enlarged chamber at the end of the gallery near the leaf base. This entire gallery may be made in that portion of the blade lying on one side of the midrib (Plate I, fig. 5).

The larvæ succeed, with great skill, in keeping the gallery walls intact, as will be noticed, even when the turns lie very close together. But when they cross an old gallery it is usually at right angles and in a straight course. All the galleries, old and new, lie in the same plane, so there is no doubt that on crossing an old one they actually tap it and do not go above or below it as might be supposed. This is borne out by dissection of the leaf.

The life history of this species has not yet been worked out. It will be noted in the figures in Plate II that the dark spots shown along the central line of the gallery indicate the distribution of the pellets of excreta, or frass. Their arrangement is much more regular than is possible in a blotch mine, the growth of which is far less regular.

The total length of the gallery or mine shown in Plate I, fig. 5, is 89 centimeters, while the mine shown in Plate I, fig. 4, is 111 centimeters in length, the average being exactly 1 meter.

*Endelus* and allied genera of Buprestidæ, for example, *Aphanisticus* and *Trachys*, will probably be found to contain many species the larvæ of which are miners in the leaves of plants of the *Asplenium nidus* group and related genera of ferns.

## A NEW BUPRESTID

Thus far but the two species of *Endelus* mentioned here have been recorded from the Philippines, but there are at least two other undescribed species in the college collection.

**Endelus calligraphus sp. nov.**

Entirely brown with uniform greenish bronze sheen over entire dorsum; head more brilliantly greenish bronze; ventrum a black bronze; legs similarly colored; eyes darker brown.

Head and pronotum microscopically reticulate and with

coarse, sparse, shallow punctures; elytra coarsely undulate-punctate. Ventral surface and legs smooth.

Head in dorsal view subglobose, front obtusely excavate (angle of 134°) (Plate II, figs. 2 and 12), frontal sulcus deep; eyes obtuse-ovate, occupying one-half the total width and three-fourths the length of head, in profile front strongly retreating so that trophi nearly touch prosternum; antennæ with segments 5 to 11 progressively acutely serrate, finely setose, segments 1 and 2 ovate, glabrous, 3 slender, 1 with few setæ, 2 and 3 bare; antennal groove somewhat sinuous (Plate II, fig. 6).

Pronotum two and one-half times as wide as long, cephalic margin feebly sinuous, except laterad where it projects cephalad with an acutely rounded angle, lateral margins obliquely arched and somewhat convergent caudad to form a slightly obtuse angle with caudal margin; caudal margin nearly straight, but with a curved submedial emargination to fit elytra; disk with two large, shallow, transverse, submedian sulci, separated by an area one-half their width, caudolateral area shallowly excavate, cephalolateral area less so and separated from former by an oblique elevation which is continued mediad to form caudal border of the transverse sulci described above; scutellum small, subequilaterally triangular, depressed mediad (Plate II, fig. 2).

Elytra very slightly wider than pronotum with sides parallel for a little more than five-eighths of their length, then evenly, roundly converging to their apices which are subsemicircular and with a few almost obsolete denticulations, humeral area with a prominent knob, apical area with a narrow, shallow obsolescent subsutural sulcus, each elytron with an obsolescent transverse depression at its first and second thirds; entire elytral area transversely confluently undulate, rugose or punctate-rugose.

Legs bronze-brown, brilliant, glabrous, basal halves of posterior femora fit into well-defined transverse pits in the sublateral portions of the metasternum; femora lenticulately flattened, with shallow, wide sulcus on apical area, between which and the body the tibia and the tarsus are hidden when at rest; tarsi with golden to pale yellow ventral pilosity.

Length, 3.65 millimeters; width at elytra, 1.50; length of head, 0.45; length of pronotum, 0.55; length of elytra, 2.65; length of scutellum, 0.25.

LUZON, Laguna, Los Baños, March 20, 1918 (*Banks*), two

bred specimens. Type No. 18397 in College of Agriculture collection, Los Baños.

This species approaches *Endelus marseulii* H. Deyr. in size; it differs from *E. æthiops* H. Deyr., which it closely resembles, in being bronzy brown, in the greater obliquity of the face, in the sides of the elytra being parallel for five-eighths of their length and lacking the strong impression and the large gibbosity at their bases.

The specific name is suggested by the galleries made by the larvæ in the leaves of *Asplenium* sp., which have the appearance of handwriting.

# ILLUSTRATIONS

[Drawings and photographs by the author.]

## PLATE I

FIG. 1. Five-chambered mine of *Endelus bakeri* Kerrem., in *Asplenium* leaf, showing crescentic mass of exereta used to close the entrance to chamber 5, and zigzag line of frass left by the larva.

2. Two-chambered mine of *Endelus bakeri*, showing two exit holes gnawed by an adult in emerging from the leaf.

3. Mine made in laboratory by *Endelus bakeri*, showing daily progress of a larva. Point 1 was reached two days after hatching; point 2, the next day; and so successively until one month thereafter point 12 was reached.

4. Leaf of *Asplenium* sp. with serpentine mine of *Endelus calligraphus* sp. nov., on both sides of the midrib. The total length of the mine is 111 centimeters. The dots represent excreta, and the enlarged chamber at the base of the leaf is the point of pupation, with the exit hole of the adult.

5. Leaf of *Asplenium* sp. with mine of *Endelus calligraphus* entirely on one side of the midrib. This mine was 89 centimeters long. Note the digression of the mine around a hole near the base of the leaf. Note also that the eggs were laid in these two leaves near the apex and the pupal chambers were made near the base.

6. Egg of *Endelus bakeri*, very greatly enlarged.

7. Unusual style of mine made by *Endelus bakeri*, in which the larva has turned back and excavated its pupal chamber near the point where the egg was laid.

## PLATE II

FIG. 1. *Endelus bakeri* Kerrem., half outline of adult.

2. *Endelus calligraphus* sp. nov., half outline of adult.
3. *Endelus bakeri*, larva, dorsal aspect.
4. *Endelus bakeri*, larva, ventral aspect of abdomen.
5. *Endelus bakeri*, adult, profile of head and thorax.
6. *Endelus calligraphus*, adult, profile of head and thorax.
7. *Endelus bakeri*, adult, ventral aspect of head and thorax.
8. *Endelus calligraphus*, adult, ventral aspect of head and thorax.
9. *Endelus calligraphus*, adult, antenna.
10. *Endelus bakeri*, adult, antenna.
11. Diagram, showing facial angle of *Endelus bakeri*.
12. Diagram, showing facial angle of *Endelus calligraphus*.

## PLATE III

FIG. 1. Leaf of *Asplenium nidus* L., showing eggs and blotch mines of *Endelus bakeri*.

2. Leaf of *Asplenium nidus* L., showing, in addition to mines, white spots caused by feeding of adult beetles of *Endelus bakeri*.

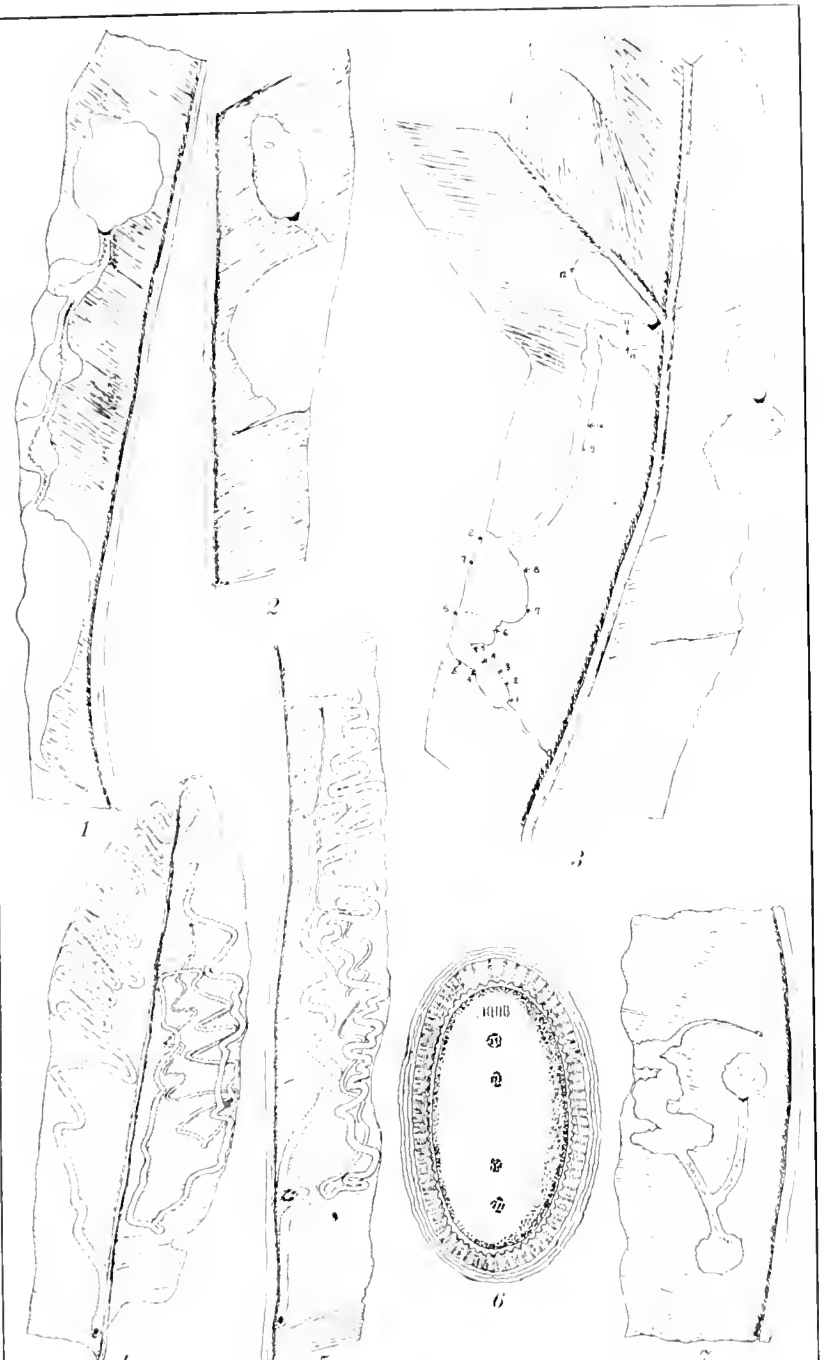



PLATE I. EGG AND MINES OF ENDELUS SPECIES.

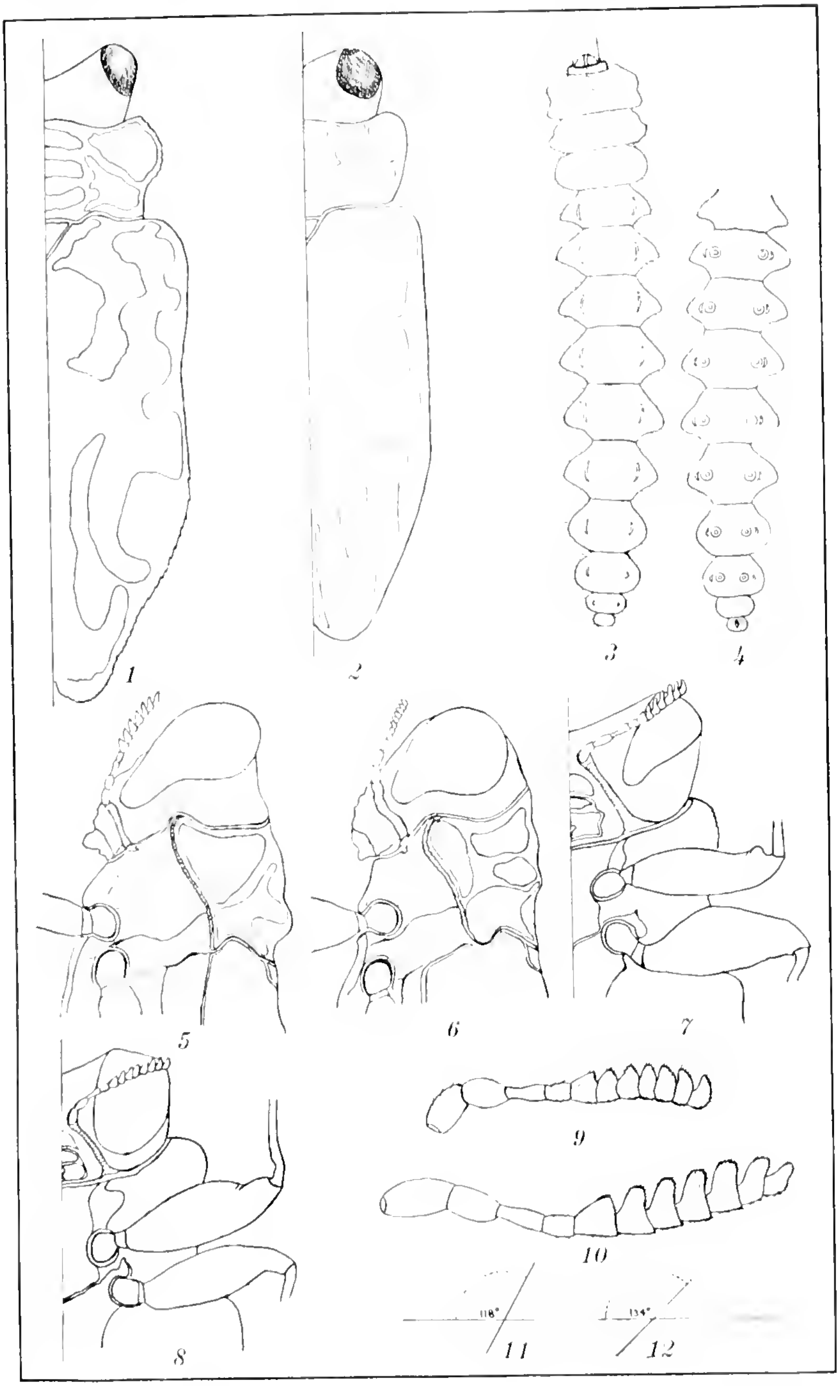



PLATE II. ENDELUS BAKERI AND E. CALLIGRAPHUS.

PLATE III. LEAVES OF ASPLENIUM NIDUS L., SHOWING MINES OF ENDELUS BAKERI.

# NOTICES OF CERTAIN FULGOROIDEA, II: THE GENUS TROBOLOPHYA

By C. F. BAKER

*Of the College of Agriculture, Los Baños*

SIX TEXT FIGURES

In 1913, Melichar[1] described a new genus, *Trobolophya*, of the family Dictyopharidæ, based upon a single specimen collected in Java by Jacobson. Just before this I had sent to Melichar a Philippine representative of the same genus, which he referred to as being the same as the Javan species.[2] After 1913 I discovered that this genus is widely and commonly distributed in the Philippines in several species, and that it occurs in western Malaysia as far north as Penang Island, Straits Settlements. In making a careful study of the accumulated material, it appears that the Javan species is quite distinct from any known Philippine form.

It is hard to explain why so generally distributed a genus, with some of the species very common, remained unknown to science until 1913, unless it be due to the fact that the species are montane and arboreal; though this is only in so far as my experience goes.

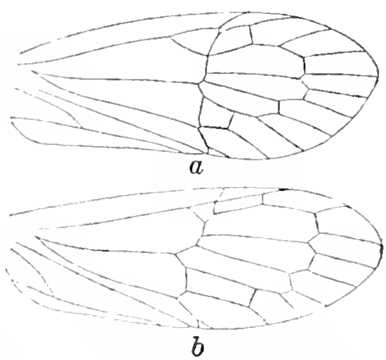


FIG. 1. *a*, *Trobolophya philippinensis* sp. nov., tegmen; *b*, *T. melichari* sp. nov., tegmen.

External anatomical features in this genus are difficult to appraise at their true comparative value since, as in many Derbidæ and other fulgorids, high and thin margins may incline one way or the other in drying, and partial collapse of certain areas may occur. It is thus very important to have ample series of specimens for study, and in most cases I have obtained these. The genitalia will, as in other Fulgoroidea, undoubtedly furnish characters of great diagnostic value, but in this case would require dissection and special preparation

[1] Notes Leyden Mus. 36 (1913) 92. [2] Loc. cit.

which would be a considerable undertaking in itself. The species so far recognized may be separated as follows:

*Synopsis of the species of Trobolophya.*

$a^1$. Intraocular portion of vertex, on median line, less than one-third length of anteocular; viewed from side, lateral margin of vertex highly arched at base; outer anteapical cell long and narrow, inner anteapical three times as long as broad (fig. 1, *b*) tegmina transversely banded ........................................ melichari sp. nov.

$a^2$. Intraocular portion of vertex, on median line, about as long as anteocular; viewed from side, lateral margin of vertex not so highly arched at base; outer anteapical cell broad, inner little longer than broad (fig. 1, *a*); tegmina never transversely banded.

$b^1$. Angle between lateral margins of vertex and front, as viewed from side, more than a right angle, and with the black spot roundish, not reaching eye.

$c^1$. Clypeus, in side view, strongly raised above the level of the front. penangensis sp. nov.

$c^2$. Clypeus, in side view, not or very little raised above level of front.

$d^1$. Lateral spot of vertex large; veins of tegmina fuscopiceous. **jacobsoni Mel.**

$d^2$. Lateral spot of vertex small; veins of tegmina piceous black. **montana** sp. nov.

$b^2$. Angle between lateral margins of vertex and front, as viewed from side, a right angle or less, and with the black spot in the form of a large band, narrowing eyeward, and nearly or quite reaching eye.

$c^1$. Vertex about as long as broad at base; smaller, paler species with dark fuscous veins........................................ philippinensis sp. nov.

$c^2$. Vertex distinctly longer than broad at base; larger, dark green species with piceous black veins................ benguetensis sp. nov.

Trobolophya melichari sp. nov.. Fig. 2, *a*, *b*.[3]

*Female*.—Length, 5 millimeters. Pale greenish, legs stramineous, becoming entirely stramineous with a darker scutellum in drying. The lateral black marks on head show through on vertex as two parallel lateral lines on apical half and as black spots at basal angles. Tegmina hyaline, veins fuscous; a narrow, irregular, curved, smoky band passes from stigma to near apex of clavus.

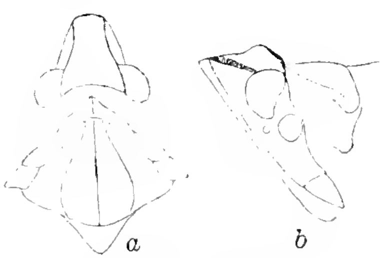



FIG. 2. *Trobolophya melichari* sp. nov.: *a*, vertex, pronotum, and scutellum; *b*, head, side view.

LUZON, Laguna Province, Mount Maquiling: Tayabas Province, Malinao. MINDANAO, Davao (coll. *Baker*). Differs from

[3] Characters given in the synopsis are not repeated in the following descriptions.

all other known species of the genus in form of head, venation, and coloration, and constitutes a distinct section of the genus. Named for Dr. L. Melichar, the founder of the genus.

**Trobolophya penangensis** sp. nov. Fig. 3, *a*, *b*.

*Female.*—Length, 6 millimeters. Head and legs stramineous, thorax sanguineous, abdomen pale green; lateral spots of head scarcely showing through on vertex; anterior tibiæ with outer border piceous. Tegmina hyaline, veins fuscous.

Penang Island, Straits Settlements (coll. *Baker*). Near to *T. jacobsoni* but distinct in form of clypeus and in coloration.

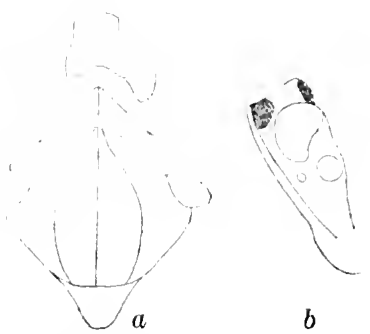



FIG. 3. *Trobolophya penangensis* sp. nov.; *a*, vertex, pronotum, and scutellum; *b*, head, side view.

**Trobolophya jacobsoni** Mel.

Melichar's detail drawings (pl. 3, fig. 1, 1*c*) are very diagrammatic. For instance, the drawing shows the lateral margins of vertex parallel throughout, which is not true for any species of the genus. Also, the position of submedian keels of scutellum are never as shown. Melichar does not mention, or show in his drawing, that the narrow caudal appendage of scutellum is separated by a distinct transverse carina connecting the posterolateral margins of scutellum; the caudal moiety is more or less concave and possibly represents a postscutellum. The vertex is nearly as long as broad, if the length is measured on the median line only; but Melichar evidently measured it at the side, or length over all, since he says "vertex once and a half as long as wide at base."

**Trobolophya montana** sp. nov. Fig. 4, *a*, *b*.

*Female.*—Length, 7 millimeters. Body deep green, head and legs stramineous; frontal and scutellar carinæ and outer margins of fore tibiæ piceous; spots on sides of head scarcely showing through on vertex. Tegmina hyaline or slightly milky clouded, longitudinal veins piceous, costa and cross veins pale fuscous.


FIG. 4. *Trobolophya montana* sp. nov.; *a*, head, side view; *b*, vertex.

*Male.*—Length, 6 millimeters. Coloring paler.

LUZON, Nueva Vizcaya Province, Imugan (coll. *Baker*),

abundant. A slightly smaller, paler form is abundant on Mount Banahao, Laguna, Luzon; this form has also been encountered at Malinao, Tayabas, Luzon.

Trobolophya philippinensis sp. nov. Fig. 5, *a*, *b*.

FIG. 5. *Trobolophya philippinensis* sp. nov.; *a*, vertex, pronotum, and scutellum; *b*, head, pronotum, and scutellum, side view.

*Female.*—Length, 5.5 millimeters. Pale green, head and legs stramineous; frontal and scutellar carinæ and outer margins of fore tibiæ fuscous; spots on sides of head showing through as small spots on vertex at outer anterior angles. Tegmina hyaline; longitudinal veins dark fuscous, darker basally and on clavus, cross veins and costa paler.

*Male.*—Length, 5 millimeters. Color paler.

LUZON, Laguna Province, Mount Maquiling and Mount Banahao (coll. *Baker*), common. A smaller, paler form occurs in the mountains of Benguet and Nueva Vizcaya. It is noteworthy that in the case of *T. montana*, a larger, deeper green form occurs in the northern mountains, and a smaller, paler form, on Maquiling and Banahao; while in the present species just the opposite is the case. This species is the one formerly referred to *T. jacobsoni* by Melichar.

Trobolophya benguetensis sp. nov. Fig. 6, *a*, *b*.

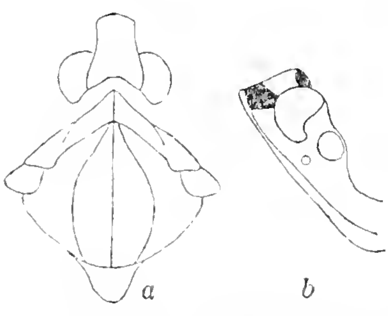


FIG. 6. *Trobolophya benguetensis* sp. nov.; *a*, vertex, pronotum, and scutellum; *b*, head, side view.

*Female.*—Length, 7 millimeters. Body, including head, deep green, sometimes with sanguineous tinting between scutellar carinæ; facial and scutellar carinæ concolorous; outer margin of fore tibiæ piceous. Lateral spots of head showing through as narrow black marks on vertex at anterolateral angles. Tegmina hyaline, stigma stramineous; veins, except costa, all piceous-black, darker basally.

LUZON, Benguet Province, Baguio; Nueva Vizcaya Province, Imugan (coll. *Baker*). This species might be readily confused with *T. montana* on superficial examination, as the two are of similar size; but they can be readily distinguished by the different form of head and by the markings.

## ILLUSTRATIONS

### TEXT FIGURES

FIG. 1. *a*, *Trobolophya philippinensis* sp. nov., tegmen; *b*, *T. melichari* sp. nov., tegmen.

2. *Trobolophya melichari* sp. nov.; *a*, vertex, pronotum, and scutellum; *b*, head, side view.
3. *Trobolophya penangensis* sp. nov.; *a*, vertex, pronotum, and scutellum; *b*, head, side view.
4. *Trobolophya montana* sp. nov.; *a*, head, side view; *b*, vertex.
5. *Trobolophya philippinensis* sp. nov.; *a*, vertex, pronotum, and scutellum; *b*, head, pronotum, and scutellum, side view.
6. *Trobolophya benguetensis* sp. nov.; *a*, vertex, pronotum, and scutellum; *b*, head, side view.

# SOY-SAUCE MANUFACTURING IN KWANGTUNG, CHINA[1]

By ELIZABETH H. GROFF

*Of Canton, China*

SEVEN PLATES

After a Chinese provides himself with rice, a little meat, and some vegetables, nothing is probably more important to him than the sauces which he eats with his food. In the book of Chau Lai (周禮),[2] the ceremonial rites of the Chau Dynasty (周朝), written before 1000 B. C., we read that the king's cook used one hundred twenty jars of sauces. Thus the written records of the Chinese show that they have been using these sauces for over three thousand years.

Soy sauce, known among the Chinese as *Ch'au yau* (抽油), "drawing oil," or *pāk yau* (白油), "white oil," is without question the best liked and most widely used. Kwangtung Province is famous all over China for the soy sauce which it produces. Canton as its capital is naturally the center of all this trade. Wholesale shops can be found in great numbers, and practically every food shop sells soy sauce. Each neighborhood also has its peddler who goes from door to door selling soy and other sauces. In Canton, jars of soy can always be seen in the making, as much of it is placed on the roofs to sun.

Sainam (西南), "southwest," a city of about 30,000 inhabitants, 50 miles southwest of Canton on the Samshui (水三), "Three Waters," Railway, is famous for the excellent quality of soy that it produces. The first-class shops in Canton all have signs advertising Sainam *Ch'au yau* (西南抽油), "Sainam soy sauce," although most of this soy is made locally in their own establishments.

The process of securing information on the making of soy sauce is lengthy and difficult, and accurate data can only be obtained after months of experiment carried on with the help of a workman who has grown up in one of these establishments.

[1] All Chinese characters in the Cantonese are romanized according to the Eitel-Genaho Dictionary, but some of the diacritical marks are omitted.

[2] Chau Lai is one of the thirteen classics of Confucius.

Frequently a soy-sauce manufacturer will smile at the questions asked him and answer: "We pay workmen to tell us those things. Why don't you do the same?"

The methods of approaching Chinese with regard to the process of manufacture are intricate. Unlimited time, knowledge of Chinese customs, and courtesy are all important factors to success. It is often necessary to work through three or four Chinese before the man can be secured who will properly introduce one to the manufacturer from whom accurate data are to be obtained. Many hours of friendly chatting over tea and cakes must be spent with these men before the business in hand can be approached. But when the final introduction takes place, one is treated as an old friend and every courtesy is tendered.

The manager of a large sauce-manufacturing plant, On Shing Lung (安盛隆), at "West Gate" (西門) Sai Mun, was approached with this method. He has given full access to his books, allowed his head workmen to spend hours talking and answering questions, and has shown a keen interest in the investigations.

## THE EQUIPMENT OF A SOY BEAN MANUFACTURING PLANT

*Grounds and buildings.*—The equipment in the largest establishments is very meager and differs from the small establishments only in capacity. In the average factory about one-third of the ground is covered with one-story buildings, which are usually built of gray brick and roofed with Canton tile. They are divided into storerooms, boiling shed, workmen's quarters, and mold room. The buildings usually surround the four sides of the plot, with a large court in the center for the sunning of the soy sauce.

*Boiling shed.*—The shed in which the beans are boiled is large enough to store sufficient raw materials for one boiling and for the board on which the beans and flour are mixed. The iron pan *t'it wok* (鐵鑊), in which the beans are boiled is semi-spherical, varies in size and price, and is sold by weight at about 14 dollars local silver [3] for 100 catties.[4] A pan large enough to boil 700 catties of beans can be purchased for about 100 dollars local silver. Its diameter is 52 inches, and its depth

[3] Local silver, at the present rate (1918), is worth about 1.05 dollars for 1 dollar Hongkong currency; 1.30 dollars Hongkong currency are worth 1 dollar United States gold.

[4] One catty is equal to one and one-third pounds.

is 32 inches. The brick oven constructed around this pan costs about 100 dollars local silver additional (Plate I).

*Mold room.*—The mold room is usually placed to the north so that the doors which control the light and ventilation, very essential to good mold, can be opened to the south and plenty of sunlight allowed to enter. This room can be made almost completely dark by the closing of these doors. It contains wooden racks on which the trays of beans and flour are placed to mold (Plate II, fig. 1).

*Jars.*—Brown earthenware cylindrical jars known as Shiuhing *kong* (肇慶缸)—now no longer manufactured—are the ones preferably used to sun the beans, salt, and water (Plate V, fig. 2). The Tsinguen *kong* (清遠缸), a brown earthenware jar of inferior quality but with the same contour as the Shiuhing jar, is now the only jar obtainable on the market. These jars are so named because they are manufactured in Shiuhing and Tsinguen, cities of Kwangtung. The Tsinguen jar leaks very easily, and the manufacturers prefer repaired Shiuhing jars to this inferior Tsinguen jar. The latter jar, 19.5 inches in diameter and 18.5 inches deep, with a capacity of 180 catties, can be purchased for 1.70 dollars local silver. About one thousand of these jars are kept in the sunning yard at one time, although at times only about two-thirds of them are in use. The Chinese believe that the jars are greatly improved by long sunning, and when space permits the jars are allowed to sun in the court yard for months at a time.

*Racks.*—The mold room is filled with crudely constructed wooden racks with horizontal partitions every 5 inches, on which are placed the trays of beans for molding (Plate II, fig. 2).

*Trays.*—Two types of trays are used, the commonest being the circular bamboo tray, *wo* (篧), made in Canton (Plate VII, fig. 1). This tray can be purchased in any size, but the most commonly used for soy making is about 3 feet in diameter with a rim of 1.5 inches. This tray is in general use in Canton for the making of many different sauces and the drying of vegetables. In order to save space many manufacturers construct light wooden frames with horizontal strips of bamboo placed close enough to support a very inferior quality of matting (Plate IV, fig. 1). These trays are made so as to fit the racks snugly. They are usually about 5 feet 2 inches long and 3 feet 9 inches wide. The matting for this size of tray can be purchased for 60 cents local silver. This seems to be an excellent method, for the matting can be replaced when worn out.

*Baskets.*—The bamboo baskets, *lo* (籮), used to drain the beans after they are boiled are round at the top and narrow toward the bottom, which is flat and more square than round. Various sizes can be purchased, but the commonest are 15 inches deep. They cost about 65 cents local silver each (Plate IV, fig. 2).

*Covers.*—Nothing is more important than a good cover with which to protect the sauce at night and when it rains (Plate V, fig. 1). A standard conical bamboo cover, 21 inches in diameter and 12 inches high, is used. These fit snugly over the top of the cylindrical jars and can be purchased for 35 cents each. This cover is called *tsim teng chuk lap* (尖頂竹笠), "pointed top bamboo."

*Raw materials.*—The raw materials used in the making of soy sauce are soy beans (Plate VI, fig. 1), flour, salt, and water. All of these are available in great quantity on the Canton market. The *wong kam tau* (黃金豆), "yellow bean," grown in Manchuria and known as coming from Ngau Chong (牛莊), is recognized as the best variety of soy bean to be used. This bean is yellow and is slightly smaller than the American soup bean; the outside coat is thick and tough and does not break apart easily after the bean is boiled. The Chinese consider this characteristic to be very important, for they wish to keep the bean as much intact as possible for the molding process. *T'o fui min* (土灰麵), local third wheat flour," comes from Kwangtung. The *shaang im* (生鹽), "raw salt," comes from Tientsin.

*Method of mixing.*—Soy sauce can be made in almost any quantity, but the beans mold much better and faster in large quantities. It is very difficult to obtain figures on the amounts of materials that are used. Each maker will tell you that he fills his iron sauce pan with beans and buys sufficient flour to mix with it and adds the salt solution at the proper time. In order to secure satisfactory data on the quantity of material used, it is necessary to be present when each process takes place.

*Boiling of beans.*—One Canton manufacturer[5] purchases 1,400 catties of beans at one time, dividing them into two boilings. This amount of beans, together with 1,200 catties of flour, provides sufficient molded beans to stock thirty-six jars. The beans are placed in a large iron pan (Plate I) and covered with about 1,100 catties of water. They are then boiled until soft. Care must be taken that the outside coat does not break.

[5] The establishment referred to on page 308.

The length of time required to soften the beans depends entirely upon the amount of heat applied. Another satisfactory process is to drop the beans into boiling water. The makers use both methods. If the beans are boiled constantly, three to four hours are sufficient for the softening process. However, in order to save time, many of the shops boil the beans at night, allowing the fire to die out and then removing the beans at about 4 o'clock in the morning. They are then placed in bamboo baskets, allowed to drain, and become almost cold before being mixed with the flour (Plate IV, fig. 2).

*Mixing of beans and flour.*—The beans are then poured upon the mixing board, two baskets at a time. Two men stand, one on either side of the board, and thoroughly mix the beans and flour with their hands. Care must be taken that each bean is covered with flour. This mixture of flour and beans is then placed on the trays to a thickness of about 1.5 inches, and the hand is used to furrow them so that they get proper ventilation (Plate II, fig. 2). The mixture remains in the mold room from one to two weeks, depending entirely upon the time of year and the weather. Much less time is needed in the hot rainy season. After the middle of November the manufacturing plants stop boiling beans and do not begin again until the spring season opens in February, as the weather during this period is unfavorable to produce the mold. After the beans are placed on the trays, they begin to mold in about three days.

*Mold.*—The natural yellow mold is probably a species of *Aspergillus*, and the undesirable black is a *Mucor.*[6] Care must be taken that only the yellow mold is used in the making of soy, and all black mold should be removed before placing in the jars of salt water (Plate VI, fig. 2).

*Method of sunning beans and flour.*—The mold from 1,400 catties of beans and 1,200 catties of flour is divided into thirty-six jars. A salt solution, of 150 catties of water to 40 catties of salt, is then poured into the jars until they are full. The salt solution is thoroughly cleaned before using by allowing the dirt to settle and then pouring off the solution. The jars of bean-flour mold and salt water are then placed in the yard to sun where they remain from two to six months (Plate V, fig. 2). The longer the period of time the better. Most of the shops,

[6] These general determinations were made by Prof. C. W. Howard, biologist at the Canton Christian College, who is making cultures for further study.

however, make the first drawing in from three to four months. At night or when it rains, the jars must be covered with bamboo covers. This sunning process results in an evaporation of the liquid in the jars; and three days before the drawing off of the soy, salt solution is used again to fill the jars. The first drawing is then made by siphon, *kwo kong lung* (過缸嚨) (Plate III, fig. 1). About 60 catties of the liquid are drawn off. This liquid is allowed to settle and is again drawn off, reducing the quantity to about 50 catties. It is then placed in clean jars and allowed to sun again for from one to six months. Some of this soy is at times allowed to sun for three years, but this is too expensive and is rarely done commercially.

*First drawing.*—This soy is called *teng ch'au* (頂抽), "first drawing." The material that remains in the jar is called *teng shi* (原豉), "first salted," and is sold as a separate sauce, used as the base of a number of different sauces or as the base for the "second drawing," *i ch'au* (二抽).

*Second drawing.*—A salt solution of 150 catties of water and 30 catties of salt is now poured on the *teng shi*, or the beans which remain in the jar from the first drawing. The jars are again placed in the sun for from one to two months. Salt water is again added three days before the drawing, after which the soy is drawn off, about 50 catties, after it is cleaned, and placed in the sun from one to two months. This is called *i ch'au* (二抽), "second drawing." The material which remains in the jar is called *ün shi* (原豉), "beginning salted," and is sold as a sauce for 4 cents per catty, used as the base of a number of other sauces and as the base for *sām ch'au* (三抽), "third drawing."

*Third drawing.*—The same method is used in the making of *sām ch'au* as in *i ch'au* and the material which remains is called *chung shi* (中豉), "middle salted." This is sold as a sauce at 2 cents per catty, used as the base of a number of different sauces and as the base for *sz ch'au* (四抽), fourth drawing."

*Fourth drawing.*—This is made the same as *i ch'au, sām ch'au,* and *sz ch'au,* and the material left in the jars is also called *chung shi* (中豉) and is sold as a sauce at 1 cent per catty; it is used as the base of a number of very cheap sauces.

*Boiling method.*—The sunning method takes so much time that many of the manufacturers boil the second, third, and fourth drawings instead of sunning them. This makes a decidedly

inferior quality of soy, but it can be sold very cheaply. After the soy is drawn from the beans, it is placed in an iron pan and boiled from two to four hours. The longer the better, but it must be boiled at the least two hours or it will not keep. It is then taken off and allowed to cool and is ready for salt. The manufacturers never boil the first drawing. They always sun this and sell it for their finest grade.

*Mixing of soy.*—It is interesting to note that of the four drawings of soy the only drawing that is sold as it is drawn is the *teng ch'au* (頂抽), "first drawing." The others are all mixed together and are sold under the names of the price they cost per catty. This mixing process is shown in the list of samples submitted.

*Prices of raw materials.*—The prices of beans and flour vary considerably, but the soy beans, *wong kam tau* (黃金豆), can be bought for about 6 cents per catty wholesale; the flour, *t'o fui min* (土灰麵), for about 6.5 cents per catty; and the salt, *shāng im* (生鹽), for about 4 cents per catty. The retail price is 8 cents per catty for the beans, 10 cents per catty for the flour, and 5 cents per catty for the salt. The manufacturers figure that the materials for one jar cost about 8.50 dollars. They expect to sell the different grades of soy and the beans left for about 14 dollars. This does not include labor, equipment, rent, etc. Candied molasses, *kat shui* (桔水), which is added to the very cheapest soy as a coloring and to sweeten it, costs about 8 cents per catty.

*Sainam soy.*—Sainam, 50 miles distant from Canton on the Samshui Railway, is famous for its soy. The establishments there are much larger than in Canton, and a superior quality of soy is produced. There are eight factories, all of about the same capacity, doing a business of over 100,000 dollars a year. The methods used in Sainam appear to be the same as those used in Canton, the only noticeable difference being in the quality of materials used. The Sainam soy makers advise buying the very best quality of raw materials, while the Canton manufacturers are content with materials of inferior grade. They believe that these inferior materials make just as good soy. The yards in Sainam also are very spacious, allowing the manufacturers to sun their product to better advantage. Ground is much less costly, and hence the sunning process is not so expensive. In one yard it was also noted that there were about five hundred jars not in use which were being sunned. Both

Canton and Sainam makers believe it is an excellent plan to sun jars. Limited space in Canton makes this impossible except on a small scale.

*Making soy from rice.*—Many of the village people make their own soy from the rice that has stuck to the bottom of the vessel in which it is boiled. A handful of rice is pressed into a ball and sprinkled with hot water. These balls are placed in a covered jar and allowed to mold. In about two weeks these balls are placed in salt solution, using one part of salt to five of water. Two parts of rice are used to three parts of salt solution. The more rice used the stronger the sauce will be. This is then sunned as the regular soy and produces a very inferior grade of rice soy, which is used by the poorer classes of Chinese as a substitute for the soy-bean sauce.

*Soy samples and prices gathered on the Canton market.*—There is no soy standard, but the different grades of soy are known in most of the shops as follows:

*T' in teng ch'au yau* (天頂抽油), "best selected drawn oil." Retailed at 40 cents local silver per catty. Made of *teng ch'au* (頂抽), "first drawing," which has been sunned four months after "drawing off."

*Tsin pat ch'au yau* (錢八抽油), "fourteen cents per catty drawing oil." This is made of the "first drawing" which has been sunned two months after "drawing off."

*Kau luk ch'au yau* (九六抽油), "eleven cents per catty *ch'au yau.*" Made of 50 per cent of the "first drawing" and 50 per cent of the "second drawing."

*Sz pat ch'au yau* (西八抽油), "eight cents per catty drawing oil." Made of 25 per cent each of "first drawing," "second drawing," "third drawing," and "fourth drawing."

*Sam luk chung ch'au* (三六抽油), "six cents per catty middle drawing." Made of 50 per cent salt solution, 50 per cent "third drawing" and "fourth drawing," and colored with candied molasses, *kat shui.*

*Sheung pāk yau* (上白油), "upper white oil." This is sold at 4 cents per catty and is made of 50 per cent salt and water and 50 per cent *sz ch'au,* "fourth drawing," and colored and sweetened with candied molasses, *kat shui.*

*Pāt sin shāng ch'au* (八仙生抽), "eight cents raw drawing." This is made of equal parts of "first drawing" and "second drawing," but after it has been drawn off the beans it is not boiled or sunned. This soy is used for soup and does not keep longer than about a week.

# ILLUSTRATIONS

## Plate I

The iron pan in which the soy beans for the making of soy sauce are boiled is used extensively in all sauce-manufacturing establishments; it varies greatly in size and is sold by weight. Note the bamboo basket fastened to a bamboo pole, by which the beans are removed from the pan.

## Plate II

Fig. 1. The dark room in which the beans and flour used in the making of soy sauce are allowed to mold. The light and the ventilation, very essential to good mold, are controlled by doors, which open to the south. Trays of beans and flour now in the process of molding. The man in the picture is the head soy maker in this establishment.

2. The beans and flour, used in the making of soy, are thoroughly mixed and placed in rudely constructed wooden racks in the dark room for the molding process.

## Plate III

Fig. 1. Soy sauce being drawn from the beans by means of a siphon. Great care must be taken not to stir the beans. The material which remains in the jar is called *teng shi*, and is sold as a separate sauce or is used as the base of the second drawing of soy.

2. The first drawing of soy, *t'in teng chau yau*, which is placed in clean jars and again sunned from two to six months.

## Plate IV

Fig. 1. This light wooden frame, with horizontal strips of bamboo placed close enough to support the matting on which the soy beans and flour are placed for molding, is frequently used in place of the circular bamboo tray in order to conserve space.

2. The bamboo baskets, in which the boiled soy beans are placed to cool and drain, are round at the top and narrower toward the bottom, which is flat and almost square.

## Plate V

Fig. 1. The conical bamboo covers, which are used to protect the jars at night and when it rains.

2. Rows of the standard-sized soy-sauce jars filled with the molded beans and flour and salt water. These remain in this position from two to six months. Note the conical bamboo covers in position for the quick covering of the jars in case of rain.

PLATE VI

FIG. 1. The soy beans shown here are natural size; they are yellow and have a thick outer coat. Great care is taken that the beans do not become mashed.

2. Beans and flour, which have been in the mold room for five days. The natural yellow mold is probably a species of *Aspergillus*, and the undesirable black mold is *Mucor*.

PLATE VII

FIG. 1. The circular bamboo tray that is commonly used in the making of soy and many other sauces and in drying vegetables. The trays have been stacked and are ready for removal to a storage shed.

2. Soy sauce ready for shipment to northern China. It is placed in sealed earthenware jars, which are incased in bamboo holders.

PLATE I. THE IRON PAN IN WHICH THE SOY BEANS ARE BOILED.

Fig. 1. The dark room.

Fig. 2. Racks in the dark room.

PLATE II.

Fig. 1. Soy sauce being drawn by means of a siphon.

Fig. 2. The first drawing of soy.

PLATE III.

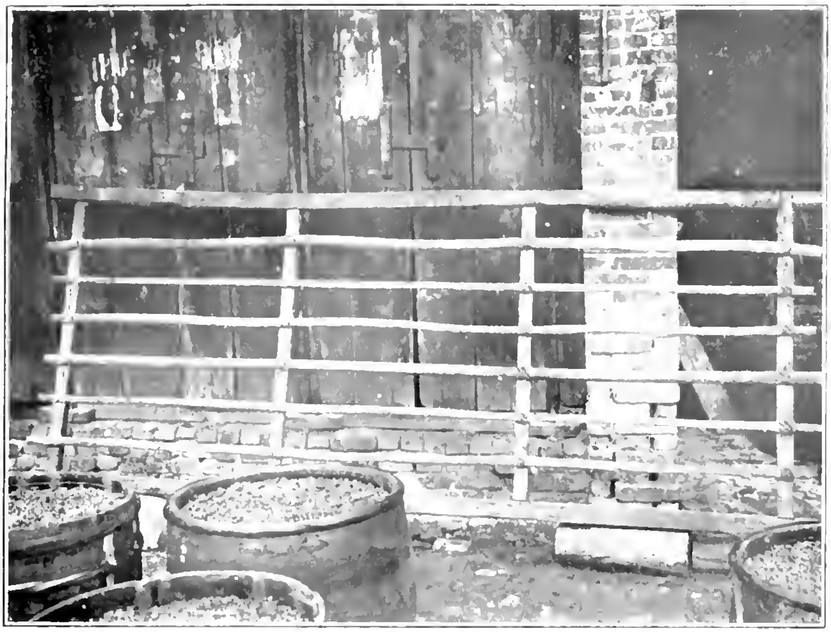


FIG. 1. A light frame, used in making soy.

FIG. 2. Bamboo baskets, in which boiled beans are cooled and drained.

PLATE IV.

Fig. 1. Conical bamboo covers.

Fig. 2. Soy-sauce jars.

PLATE V.

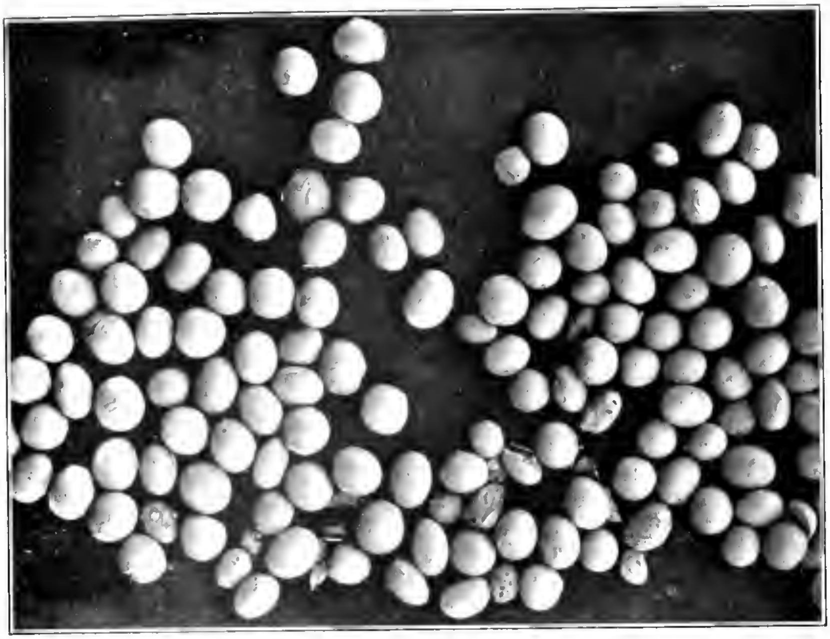


FIG. 1. Soy beans, natural size.

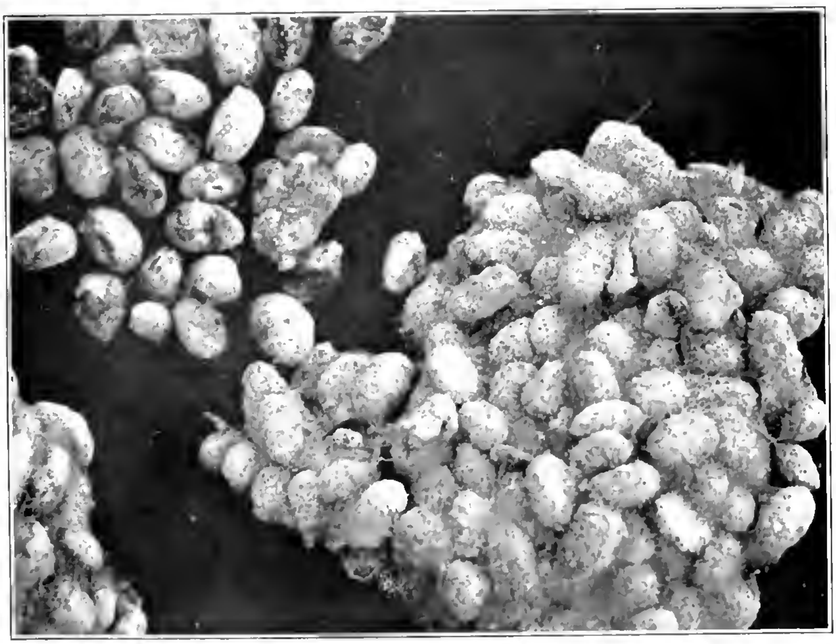


FIG. 2. Soy beans and flour five days in the mold room.

PLATE VI.

Fig. 1. Circular bamboo trays.

Fig. 2. Soy sauce ready for shipment.

PLATE VII.

# REVIEWS

The | Medical Clinics | of | North America | November, 1918 | published bi-monthly by | W. B. Saunders Company | Philadelphia and London | Pp. 645–920.

The Philadelphia Number, Volume II, No. 3, contains the following papers:

The influenza epidemics of 1889 and 1918, by Dr. Alfred Stengel.
Influenza and some of its complications, by Dr. H. R. M. Landis.
The surgical complications and sequelæ of influenza, by Dr. John B. Deaver.
Bacteriologic study of sputum in the recent epidemic, by Dr. Charles W. Burr.
Bacteriology of influenza, by Lieut. Eugene A. Case.
Nose, throat, and ear affections complicating or following the recent epidemic of so-called influenza, with a ventured interpretation of their significance, by Dr. J. Leslie Davis.
Influenza in children, by Dr. Maurice Ostheimer.
Feeding babies during their second year, by Dr. Maurice Ostheimer.
Sciatica, by Dr. Thomas McCrae.
Intraspinal therapy in syphilis, by Dr. Jay Frank Schamberg and Dr. Albert Strickler.
Chylothorax, by Elmer H. Funk.
Aortic aneurysm with esophageal rupture, by Elmer H. Funk.
Tuberculosis and pregnancy, by Elmer H. Funk.
Medical treatment of biliary affections, by Dr. Martin E. Rehfuss.
Dilatation of the colon in children, with especial reference to the idiopathic form, by Dr. J. P. Crozer Griffith.
Cerebral palsies of children, by Dr. Charles S. Potts.
Diabetes, by Dr. Leon Jonas.
X-ray diagnosis of lung diseases, by Dr. David R. Bowen.
Physiologic psychiatry, by Dr. S. D. W. Ludlum.
Influenza—Remarks upon symptoms, prevention, and treatment, by Dr. David Riesman.

Volume I September–December, 1918 Number 1 | Quarterly Medical Clinics | A Series of Consecutive Clinical Demonstrations and Lectures | by Frank Smithies, M. D., F. A. C. P. | [four lines of titles] Augustana Hospital Chicago published by Medicine and Surgery Publishing Company, Inc. Metropolitan Building St. Louis | Paper, pp. 1–188, $1.50.

FROM THE PREFACE

For some time, it has been the practice to have a clerk report my Clinics and Lectures given at Augustana Hospital to the Senior Students of the School of Medicine of the University of Illinois. The notes taken by the clerk have been edited,

mimeographed and given to the students at each succeeding Clinic. This procedure has proved more valuable than when students themselves made notes. It has also enabled me to keep a record of the subjects presented, has avoided repetition and furnished a definite material from which examination questions might be selected.

Frequently, students and visiting physicians have suggested that the Clinics and Lectures be issued in consecutive order and in form more substantial than loose mimeographed sheets. Difficulties attendant upon such arrangement finally have been overcome and this volume contains the bulk of the clinical matter presented during the past three months. It is hoped that each quarter similar collections of Clinics and Lectures may be issued and that the venture may prove as useful to medical men, generally, as it has proved already to a limited group of students.

Ultra Violet Rays In | Modern Dermatology | Including the evolution of artificial | light rays and therapeutic | technique | by | Ralph Bernstein, M. D. | Philadelphia, Pa. | [eighteen lines of titles] | author of "Elementary dermatology"—numerous | brochures on skin diseases, etc. | illustrated | Achey & Gorrecht | 5–9 North Queen Street | Lancaster, Pennsylvania | Cloth, pp. i-xiii + 1–162.

FROM THE PREFACE

The efficacy of ultra violet rays in the practice of dermatology is now thoroughly established, and its bactericidal action, its anti-pruritic and analgesic effects, as well as its reconstructive action upon epidermal cells and its constitutional effect upon the general economy, cannot now be denied.

The author has been prompted to write this book because no American author has heretofore attempted it, the profession relying entirely upon the writings of their European colleagues.

It is the author's intention to present the subject as briefly as possible with clearness, and with no intention of going into histo-pathologic details. The mere thought in mind will be to give in a practical way to the profession the results of his clinical experience with the use of ultra violet radiations in the treatment of the various skin diseases for which he has found the ultra violet light a desirable agent.

The author has thoroughly gleaned the literature of the day and hereby gives credit for the material which he has used therefrom to the foreign writings of Morris, Dore, Bach, Wagner, Kruger, and Blaschko, and to the following writers from our own continent: Martin, MacKee, Jordan, Plank, Collins, and Allen.

THE PHILIPPINE

# JOURNAL OF SCIENCE

VOL. XV OCTOBER, 1919 No. 4

# FORMOSAN TERMITES AND METHODS OF PREVENTING THEIR DAMAGE

By MASAMITSU OSHIMA

*Of the Institute of Science, Government of Formosa*

THIRTEEN PLATES AND FIVE TEXT FIGURES

CONTENTS



## INTRODUCTION

One of the most serious problems in the Tropics with regard to man's industry is to discover a method of preventing the damage caused by termites. Because of their subterranean habits and insidious methods of attack, termites are very difficult to destroy. Moreover, as stated by Dr. K. Escherich:[1] "Nichts ist vor ihren Kiefern und zerstörenden Sekreten sicher

[1] Die Termiten (1909).

ausser Eisen und Stein." Such being the case, not only is the extermination of these insects almost impossible, but also preventive measures against their damage are difficult to apply.

Fortunately, Japan is located in a temperate region; and, therefore, her people have not been obliged to pay attention to these formidable pests. However, one species, *Leucotermes speratus* Kolbe, which very often causes somewhat serious damage to wooden structures, has been recorded in Japan since 1724. About twenty years ago, Japan occupied Formosa, which lies in a semitropical region; that is, in the western Pacific Ocean, between the southern and eastern China Seas. In this possession the people have been compelled to fight against the common pest of the Tropics, and the investigation of the biology of termites has become one of the most important problems of the architect and the entomologist.

In Formosa and in Japan there are fourteen species of termites, four of which, namely *Coptotermes formosanus*, *Leucotermes speratus*, *Leucotermes flaviceps*, and *Odontotermes formosanus*, are known as pests of wooden structures. *Coptotermes formosanus*, which is distributed in Formosa, Riu Kiu Islands, and in the southern parts of Japan proper, is especially formidable to buildings. It is certain that the other three attack woodwork, and wooden structures as well, but their ravages are negligible in comparison with those of *Coptotermes formosanus.*

During the last ten years, I have been investigating the Japanese termites, especially the habits of *Coptotermes formosanus.* I approached the problem of the method for prevention with the following ideas as a working basis:

1. Some changes are necessary with regard to the construction of buildings in the Tropics in order to prevent damage by termites.
2. The value of termite-proof building construction is not absolute, unless all sorts of nonresistant timbers are eliminated from the building materials.
3. If it shall be proved that the elimination of nonresistant timbers is practically impossible, it becomes necessary to treat them chemically or physically in order to confer a special resistant property.
4. It is necessary to prove whether or not there are naturally resistant timbers in the Tropics.
5. If there are naturally resistant timbers, an investigation with the object of discovering the cause of resistance becomes important.
6. If the causes are definitely known, methods of artificially treating nonresistant timbers will be more easily discovered.

By the kind and valuable assistance of Mr. Kinzo Kafuku, former expert chemist of the Government Institute of Science,

Formosa; Mr. Tetsukichi Katayama, chief of the chemical department of the same institute; and Mr. Saichi Tasaki, my assistant, I have carried on my investigations and very fortunately have gained some satisfactory results, which are recorded in the following pages. Here I wish to express my sincere thanks for the courtesy shown by those gentlemen and to Dr. Tomoe Takaki, former director of the above-mentioned institute, through whose most courteous assistance I have been able to continue my work for so many years.

## DESCRIPTIONS OF THE FORMOSAN TERMITES INJURIOUS TO WOODEN STRUCTURES

### Family MESOTERMITIDÆ Holmgren

#### Subfamily COPTOTERMITINÆ Holmgren

#### Genus COPTOTERMES Wasmann

**Coptotermes formosanus** Shiraki. Plate I, figs. 1 to 3.

*Coptotermes formosanus* SHIRAKI, Trans. Ent. Soc. Jap. 2 (1909) 239; OSHIMA, Rep. Term. 1 (1909) 33, pl. 1, figs. 1–3; pl. 2, figs. 11, 12; Rep. Term. 3 (1912) 75, pl. 1, figs. 8, 28; pl. 2, figs. 3, 21; Philip. Journ. Sci. § D 8 (1913) 276; Rep. Term. 4 (1914) 2; HOLMGREN, Termitenstudien 4 (1913) 76, pl. 2, fig. 10; HOZAWA, Journ. Coll. Sci. Tokyo 35 (1915) 92, pl. 3, figs. 18–20, text figs. 22–25.

*Coptotermes gestroi* OSHIMA, Zool. Mag. Tokyo 22 (1910) 376; Rep. Term. 2 (1911) 5; NAWA, Insect World 14 (1910) 597.

*Coptotermes formosae* HOLMGREN, Termitenleben auf Ceylon (1911) 192; Termitenstudien 2 (1911) 74; Annot. Zool. Jap. 8 (1912) 121; YANO, Rep. Jap. For. Exp. Station 9 (1911) 62, pl. 4, figs. 12–20.

*Imago*.—Head brown; anteclypeus whitish; postclypeus, antennæ, labrum, and labial palpi brownish yellow; pronotum yellowish brown, with Y-shaped marking; mesonotum, metanotum, and abdomen pale brown; legs yellow, tibia and tarsus darker; head, thoracic plates, and abdominal tergites densely pilose; wing stumps beset with hairs.

Head round, fontanelle distinct; antennæ 21-jointed, second joint cylindrical, nearly as long as third and fourth taken together; third joint short, ring-shaped; eye round, markedly prominent; ocellus oval, separated from eye by a distance less than its shorter diameter; anteclypeus trapezoidal, narrower than postclypeus, the latter short and slightly swollen; pronotum semilunar, anterior border concave, posterior border

bilobed, posterolateral corners rounded; mesonotum and metanotum narrower than pronotum, their posterior borders slightly concave; wing stumps subequal in size, anterior ones overlapping base of posterior; wings hyaline, costal margin yellowish, veins yellowish at base; wing membrane densely beset with minute hairs, radius nerve of anterior wing parallel to costal margin; median nerve faint, nearer to cubitus than to radius, with no branch; cubitus below middle of wing, not reaching tip, with about seven branches, of which the proximal four are stronger; median nerve of posterior wing starts from proximal portion of radius.

*Measurements of the imago.*

| | mm. |
|---|---|
| Length of body with wings | 14.00 |
| Length of body without wings | 6.00 |
| Length of head | 1.40 |
| Width of head | 1.31 |
| Width of pronotum | 1.31 |
| Length of pronotum | 0.87 |
| Length of anterior wing | 11.00 |

*Queen.*—Head and thorax similar to those of imago; mesonotum and metanotum with a pair of triangular wing stumps; abdomen much enlarged; abdominal tergites pale reddish brown, separated from each other by a distance about four times as great as its length; abdominal integument milk white.

*Measurements of the queen.*

| | mm. |
|---|---|
| Length of body | 21.00 |
| Length of abdomen | 19.00 |
| Width of abdomen | 5.50 |

*King.*—All the characters agree very well with those of the imago; abdomen not enlarged; thorax provided with two pairs of triangular wing stumps.

*Substitute queen.*—Head yellow; postclypeus somewhat paler; anteclypeus whitish; mandibles pale yellow, with brown tips; antennæ and legs pale yellow; thoracic plates yellow; abdomen milk white, with pale yellow abdominal tergites; head and thoracic plates very coarsely beset with minute hairs; abdominal tergites smooth.

Head round, Y-suture distinct, whitish; fontanelle round, whitish, situated at the center of the suture; eye round, with no pigment, slightly prominent; ocellus round, whitish, separated from eye by a distance greater than its diameter; postclypeus trapezoidal, more than twice as broad as long; anteclypeus slightly swollen; labrum tongue-shaped, entirely overlapping

mandibles; antennæ 17-jointed, second to fourth joints equal in length; pronotum semilunar, anterior border bilobed, posterior border clearly indented at middle, anterolateral corners rounded; mesonotum and metanotum much broader than pronotum, their posterior borders nearly straight, their posterolateral corners strongly projected posteriorly, forming rudimental wing pads; abdomen more or less enlarged, chitinous plates crescent-shaped.

*Measurements of the substitute queen.*

| | mm. |
|---|---|
| Length of body | 12.00 |
| Length of abdomen | 9.00 |
| Width of abdomen | 3.50 |
| Length of head | 1.25 |
| Width of head | 1.34 |
| Width of pronotum | 1.25 |
| Length of pronotum | 0.78 |

*Substitute king.*—Unknown.

*Soldier.*—Head yellow; mandibles dark brown; labrum brownish yellow; antennæ somewhat paler; pronotum pale yellow; abdomen and legs pale straw color; head coarsely pilose; thoracic plates hairy; abdominal tergites densely covered with short spiny hairs.

Head suborbicular, posterior border rounded, sides arcuate, strongly converging anteriorly; fontanelle distinct, opening directed forward, situated just behind the base of postclypeus; antennæ 15-jointed, second joint quadrate, longer than third, the latter narrowest and shorter than fourth; mandibles saber-shaped, slender, with incurved, piercing tip, cutting edge toothless, labrum lancet-shaped, tip hyaline, reaching middle of mandible; anterior border of anteclypeus slightly convex; postclypeus very short, not separated from forehead; pronotum subreniform, narrower than head, anterior and posterior borders slightly bilobed, lateral borders rounded, converging posteriorly; mesonotum oval, the former slightly narrower than pronotum, while the latter is broader.

*Measurements of the soldier.*

| | mm. |
|---|---|
| Length of body | 5.00 |
| Length of head with mandibles | 2.37 |
| Length of head without mandibles | 1.56 |
| Width of head | 1.18 |
| Width of pronotum | 0.84 |
| Length of pronotum | 0.50 |

*Worker.*—Head, thorax, and abdomen milk white, densely covered with short spiny hairs.

Head spherical; antennæ 15- or 16-jointed, second joint longer than third, fourth joint ring-shaped; clypeus trapezoidal, anterior border straight, boundary between anteclypeus and postclypeus indistinct; pronotum much narrower than head, semilunar.

*Measurements of the worker.*

| | mm. |
|---|---|
| Length of body | 4.50 |
| Width of head | 1.15 |
| Width of pronotum | 1.00 |

*Distribution.*—South China (Foochow and Amoy); Formosa; Kotosho (Botel Tobago Island); Riu Kiu Islands; Shikoku; Kiushiu; southern part of Honshu, chiefly the coasts along the Inland Sea.

## Subfamily LEUCOTERMITINÆ Holmgren

### Genus LEUCOTERMES Silvestri

**Leucotermes (Reticulitermes) flaviceps Oshima.**

*Termes* (*Leucotermes*) *flavipes* OSHIMA, Rep. Term. 1 (1909) 30, pl. 1, figs. 4–8; Zool. Mag. Tokyo 22 (1909) 345.

*Leucotermes flavipes* SHIRAKI, Trans. Ent. Soc. Jap. (1909) 231; OSHIMA, Rep. Term. 2 (1911) 3; NAWA, Insect World 15 (1911) 14.

*Leucotermes flaviceps* OSHIMA, Rep. Term. 3 (1912) 74, pl. 1, fig. 10; pl. 2, figs. 15–17; Philip. Journ. Sci. § D 8 (1913) 277.

*Leucotermes* (*Reticulitermes*) *flaviceps* OSHIMA, Rep. Term. 4 (1914) 2.

*Imago.*—Head chestnut brown, antennæ and abdomen somewhat darker; pronotum yellow; mesonotum and metanotum dark brown; femur dark; tibia and tarsus yellow; head, thorax, and abdomen densely covered with hairs.

Head quadrate, posterior border rounded; clypeus yellow, nearly twice as broad as long, slightly swollen, boundary between anteclypeus and postclypeus indistinct; labrum tongue-shaped, as long as broad; eyes rather small; ocellus separated from eye by a distance equal to its diameter; antennæ very long, nearly twice as long as length of head, 17-jointed, second joint as long as fourth, third joint smallest, shorter than second; pronotum narrower than head, semilunar, anterior border nearly straight, posterior border rounded, weakly incurved at middle; posterior border of mesonotum and metanotum rounded; wing stumps subequal, the anterior scarcely covering base of posterior; wings fuscous, with brownish costal margin; radius nerve of anterior wings near and parallel to costal not branched; median nerve midway between radius and cubitus, connected with the former

by many short branches, cubitus with about ten branches, not reaching tip of wing, its tip anastomosing and connecting with median nerve.

*Measurements of the imago.*

| | mm. |
|---|---|
| Length of body with wings | 9.00 |
| Length of body without wings | 4.50 |
| Length of head | 1.03 |
| Width of head | 1.00 |
| Width of pronotum | 0.90 |
| Length of pronotum | 0.59 |
| Length of anterior wing | 8.00 |

*Soldier.*—Head yellow; mandibles reddish brown; thorax and abdomen yellowish white; antennæ and legs straw-colored; head moderately pilose, thorax densely provided with short, spiny hairs; abdominal tergites densely pilose.

Head cylindrical, posterior border rounded, anterior border nearly straight, sides straight and parallel; clypeus very short, indistinctly separated from forehead; labrum lancet-shaped, tip whitish, scarcely reaching middle of mandibles; mandible saber-shaped, tip incurved, cutting margin smooth; antennæ 14- to 16-jointed; third joint smallest, nearly half as long as second; fourth joint slightly shorter than second; fontanelle indistinct; pronotum heart-shaped, anterior border bilobed, posterior border nearly straight, sides converging posteriorly, mesonotum and metanotum narrower than pronotum.

*Measurements of the soldier.*

| | mm. |
|---|---|
| Length of head | 5.00 |
| Length of head with mandibles | 2.50 |
| Length of head without mandibles | 1.75 |
| Width of head | 1.03 |
| Width of pronotum | 0.78 |
| Length of pronotum | 0.47 |

*Worker.*—Head yellowish white; thorax, abdomen, antennæ, and legs whitish; head, thorax, and abdominal tergites densely pilose.

Head round, slightly widening anteriorly; length of post-clypeus less than half its width; antennæ 14-jointed, second joint nearly as long as third, fourth joint as long as third; pronotum narrower than head, anterior border bilobed, slightly raised, posterior border nearly straight, sides converging posteriorly; mesonotum nearly as broad as pronotum; metanotum much broader than mesonotum.

*Measurements of the worker.*

| | mm. |
|---|---|
| Length of head | 4.00 |
| Width of head | 1.03 |
| Width of pronotum | 0.69 |

*Distribution.*—Formosa (Taihoku, Horisha, and Koshun); Kotosho (Botel Tobago Island).

*Remarks.*—The present species is very closely related to *Leucotermes speratus*, from Japan proper. It is very hard to draw a fast line between the imagoes of the two species; however, the soldiers of the two species distinctly differ as follows:

$a^1$. Head narrow and long, 1.75 to 1.81 millimeters long, 1.03 to 1.09 millimeters broad; lateral borders of head straight and parallel; posterior border of pronotum nearly straight.......... *L. flaviceps*.

$a^2$. Head rather broad and short, 1.56 to 1.71 millimeters long, 1.06 to 1.09 millimeters broad; lateral borders of head convex, slightly converging anteriorly; posterior border of pronotum clearly indented at middle.......... *L. speratus*.

In addition, the swarming seasons of the two species are quite different. The winged forms of *L. flaviceps* swarm in the beginning of January, while those of *L. speratus* swarm in April or May.

## Family METATERMITIDÆ Holmgren

### Genus **ODONTOTERMES** Holmgren

Odontotermes (Cyclotermes) formosanus (Shiraki). Plate I, figs. 4 to 6.

*Termes formosana* Shiraki, Trans. Ent. Soc. Jap. 2 (1909) 234; Oshima, Rep. Term. 3 (1912) 81, pl. 1, figs. 7, 26, 27; pl. 2, figs. 11, 18.

*Termes vulgaris* Shiraki, Trans. Ent. Soc. Jap. 2 (1909) 233; Oshima, Rep. Term. 1 (1909) 37, pl., figs. 9, 10; Zool. Mag. Tokyo 22 (1910) 379; Rep. Term. 2 (1911) 7; Matsumura, Schädl. u. Nützl. Insekt. v. Zuckerrohr Formosa (1910) 2, pl. 1, figs. 2–4.

*Odontotermes (Cyclotermes) formosanus* Holmgren, Termitenstudien 3 (1910) 38; Termitenstudien 4 (1913) 116, pl. 4, fig. 11; pl. 5, fig. 11; Hozawa, Journ. Coll. Sci. Tokyo **35** (1915) 105, pl. 3, figs. 21–23, text figs. 26–28.

*Odontotermes formosanus* Holmgren, Annot. Zool. Jap. **8** (1912) 127.

*Odontotermes (Cyelotermes) formosana* Oshima, Philip. Journ. Sci. § D **8** (1913) 278.

*Imago.*—Head, thorax, and abdomen chestnut; anteclypeus yellowish white; antennæ, labial palpi, T-shaped marking and anterolateral corners of pronotum, and legs brownish yellow;

wings fuscous, with yellowish subcostal band; head, thorax, and abdomen densely pilose.

Head round; fontanelle somewhat elevated, minute; antennæ 19-jointed, second joint twice as long as third, fourth joint as long as third; eye round and prominent; ocellus oval, separated from eye by a distance more than its longest diameter; postclypeus swollen, width more than twice its length; pronotum narrower than head, subsemilunar, anterior border nearly straight, sides strongly converging posteriorly, posterior border rounded, slightly curved at middle; mesonotum and metanotum longer than pronotum, their posterior borders strongly indented at middle; anterior wing stumps somewhat larger than posterior, not covering the latter; radius nerve of anterior wing runs near and parallel to costal, with no branch; median nerve starts from proximal part of cubitus, giving off four bifurcating branches at the apical area, cubitus with about ten branches, not reaching tip of wing; median nerve of posterior wing starts from basal part of radius.

*Measurements of the imago.*

| | mm. |
|---|---|
| Length of body with wings | 27.00 |
| Length of body without wings | 9.00 |
| Length of head | 2.20 |
| Width of head | 2.00 |
| Width of pronotum | 24.00 |
| Length of pronotum | 1.20 |
| Length of anterior wing | 24.00 |

*Soldier.*—Head reddish yellow; mandibles reddish brown; labial palpi, antennæ, and legs yellow; abdomen pale yellowish white; head, thoracic plates, and abdominal tergites sparingly pilose, long hairs mingling with subequal minute hairs.

Head ovoid, longer than broad, sides slightly converging anteriorly; antennæ 16-jointed, third joint smallest, second joint about twice as long as third, fourth joint shorter than third; mandibles saber-shaped, with incurved and upcurved tip, each mandible provided with one tooth, of which the left one is stronger and distinct; labrum lancet-shaped, scarcely reaching middle of mandible, with acutely rounded tip; clypeus very short, not separated from forehead; pronotum slightly broader than long, anterior border elevated and distinctly bilobed, posterior border rounded, concave at middle; mesonotum oval, nearly as broad as pronotum, posterior border curved at middle; metanotum much broader than pronotum, posterior border rounded.

*Measurements of the soldier.*

| | mm. |
|---|---|
| Length of body | 4.50 |
| Length of head with mandibles | 2.12 |
| Length of head without mandibles | 1.40 |
| Width of head | 1.12 |
| Width of pronotum | 0.74 |
| Length of pronotum | 0.47 |

*Worker.*—Head yellow; clypeus somewhat paler; antennæ and legs straw-colored, thorax and abdomen whitish; head moderately pilose; thorax and abdominal tergites densely provided with minute hairs.

Head spherical; antennæ 17-jointed, third joint smallest, second joint elongate, more than twice as long as third, fourth joint slightly longer than third; postclypeus swollen, more than twice as broad as long, anterior border concave; anteclypeus whitish, anterior border convex; pronotum saddle-shaped, much narrower than head, anterior border strongly elevated, indented at middle, posterior border rounded, curved at middle.

*Measurements of the worker.*

| | mm. |
|---|---|
| Length of body | 3.50 |
| Width of head | 1.31 |
| Width of pronotum | 0.62 |

*Distribution.*—*Odontotermes formosanus* is one of the commonest species in Formosa. It has been recorded from Ishigakijima and South China (Amoy and Foochow).

*Remarks.*—This species attacks living plants. It is a serious pest to sugar cane and young camphor trees.

## CERTAIN HABITS OF COPTOTERMES FORMOSANUS SHIRAKI

### DIFFERENT CASTES IN THE COLONY

Generally the members of a termite colony differ greatly at different times of the year. Eggs and newly hatched larvæ of *Coptotermes formosanus* are most numerous in the summer; winged forms and nymphs are not present after the swarming season (from the end of May to the beginning of June); nymphs increase in number in the spring, becoming most abundant in April; at the end of May the nymph changes to an imago and usually swarms during the first ten days of June. A complete colony contains the following castes:

1. Newly hatched larvæ. The heads of all are alike in dimensions and are provided with 10-jointed antennæ.
2. Larvæ of soldier, derived from 1. Distinctly differs from the other castes in having somewhat elongate, toothless mandibles and suborbicular head.

3. Larvæ of worker, derived from 1. Large-headed and provided with clearly denticulated mandibles, the tip and the inner margin of which are more or less brown.
4. Larvæ of royal form, derived from 1. Small-headed; other external characters are similar to those of worker larvæ.
5. Nymph of royal form. The members of this caste are provided with two pairs of wing pads and one pair of nonpigmented eyes and ocelli; body milk white.
6. Winged forms with pigmented eyes. Body reddish brown. At the beginning of May vast numbers of this caste are found in the nests; they emerge from the old nest early in June.
7. A single queen, derived from a female of the winged form. Abdomen greatly enlarged, with two pairs of triangular wing stumps on the thorax.
8. A single king, derived from a male of the winged form. Abdomen normal, with two pairs of triangular wing stumps on the thorax.
9. Substitute royal forms. It is certain that there are several kings and queens belonging to this class; however, the substitute king is not known. The substitute queen which was collected in Kiushiu by Mr. Tatsuo Yoneyama, engineer of the Imperial Railway, is 12 millimeters long; head yellow, abdomen milk white, thorax with no wing stumps. This caste is very rare in the colony of *Coptotermes formosanus*. According to Yoneyama's information, the nest which contained this queen was orphaned and some fifteen of the same form were captured at the same time.

The following are descriptions of young forms, given somewhat fully:

*Newly hatched undifferentiated larvæ.*—Head, thorax, and abdomen milk white and densely provided with minute hairs.

Head squarish, sides strongly converging anteriorly, posterior border nearly straight, posterolateral corners rounded; antennæ 10-jointed, joints enlarging apically, first joint quadrilateral, second joint slightly shorter than first, broader anteriorly, third joint semidivided, slightly shorter and narrower than second, fourth to sixth joints ring-shaped, seventh to ninth joints spherical, apical joint elongate, oval, slightly narrowed anteriorly; anteclypeus short, its anterior border rounded; postclypeus not separated from forehead; labrum tongue-shaped, longer than broad, anterior border rounded; mandibles triangular, tip obtusely rounded, cutting margin of both sides with traces of minute teeth; pronotum narrower than head, crescent-shaped, posterior border rounded; mesonotum and metanotum broader than pronotum.

*Measurements.*

| | mm |
|---|---|
| Length of body | 1.50 |
| Length of head | 0.27 |
| Width of head | 0.52 |
| Width of pronotum | 0.26 |
| Length of pronotum | 0.10 |

*Larva of soldier, with 12-jointed antennæ.*—All parts of body milk white; tips of mandibles pale brown; head coarsely pilose; thoracic plates hairy; abdominal tergites densely covered with short hairs.

Head broadly oval, slightly longer than broad, broader anteriorly; fontanelle indistinct; antennæ 12-jointed, second joint nearly as long as third, third joint narrowest, fourth joint shorter than second, fifth to ninth joints spherical, apical joint elongate, narrower anteriorly; clypeus twice as broad as long, anterior border rounded, boundary between anteclypeus and postclypeus indistinct; labrum lancet-shaped, mandibles rather short and broad, with pointed and incurved tip; pronotum narrower than head, oval, anterior and posterior borders rounded; mesonotum and metanotum round, the former narrower than the latter and broader than pronotum.

*Measurements.*

| | mm. |
|---|---|
| Length of body | 4.00 |
| Length of head with mandibles | 1.50 |
| Length of head without mandibles | 0.93 |
| Width of head | 0.90 |
| Width of pronotum | 0.53 |
| Length of pronotum | 0.31 |

*Larva of royal form, with 12-jointed antennæ.*—Head, thorax, and abdomen whitish and sparingly provided with minute hairs.

Head round, nearly as long as broad, anterior corners of transversal band yellowish brown; postclypeus slightly swollen, longitudinally depressed along median line; anteclypeus as long as postclypeus, anterior border rounded; labrum tongue-shaped, overlapping the mandibles; mandible triangular, cutting edge dark brown; antennæ 12-jointed, second joint as long as fourth, third joint smallest, nearly half as long as second; pronotum ovoid, anterior border convex, slightly emarginate at middle, posterior border rounded; mesonotum and metanotum broader than pronotum, mesonotum narrower than metanotum.

*Measurements.*

| | mm. |
|---|---|
| Length of body | 3.50 |
| Length of head | 0.84 |
| Width of head | 0.87 |
| Width of pronotum | 0.50 |
| Length of pronotum | 0.21 |

*Remarks.*—In the present phase the external characters of the larva of the worker are similar to those of the larva of the royal form, except the size of the head. The former is provided

with a much larger head, measuring 0.91 to 0.94 millimeter long and 0.88 to 0.91 millimeter broad; while the latter has a smaller head, measuring 0.84 to 0.91 millimeter long and 0.84 millimeter broad. This distinction between the two forms is observable in the earlier stage when the larvæ are provided with 11-jointed antennæ.

*Nymph of royal form.*—Head, thorax, and abdomen milk white; eyes nonpigmented; head and pronotum sparingly pilose; wing pads with a few short hairs; abdominal tergites densely covered with minute hairs.

Head round, slightly broader than long; fontanelle spotted, round and white, situated at center of head; eyes round and prominent; ocellus separated from eye by a distance equal to its diameter; postclypeus short, anterior border nearly straight, shorter than posterior; anteclypeus as long as postclypeus, with rounded anterior border; labrum tongue-shaped, sides slightly converging posteriorly, tip and cutting margin of mandibles dark brown; antennæ 19-jointed, second joint longer than third, fourth joint nearly as long as second, semidivided; pronotum semicircular, anterior border concave, posterior border indented at middle, anterolateral corners rounded; lateral parts of mesonotum and metanotum much produced posteriorly, forming primitive wing cases, which are provided with rudimental veins.

*Measurements.*

| | mm. |
|---|---|
| Length of body | 8.50 |
| Length of head | 1.15 |
| Width of head | 1.31 |
| Width of pronotum | 1.40 |
| Length of pronotum | 0.93 |

THE FOUNDATION OF A NEW COLONY

In Formosa the swarming of *Coptotermes formosanus* takes place at the end of May or early in June, while in Japan proper the winged individuals swarm a little later; that is, at the end of June.

TABLE I.—*Records of the swarming season of Coptotermes formosanus.*

| Year. | Formosa. | Japan proper. |
|---|---|---|
| 1912 | No record | June 12 to 19; at Marugame. |
| 1913 | June 1; at Taihoku | June 26; at Mitajiri. |
| 1914 | June 3; at Taihoku | June 25; at Gifu. |
| 1915 | June 1; at Taihoku | No record. |
| 1916 | June 4; at Taihoku | Do. |
| 1917 | June 8; at Taihoku | Do. |

After the adults have rapidly emerged from the parent nest in a vast swarm and have flown a short distance in an irregular, wobbly manner, they fall to the ground. As soon as they reach the ground, they cast the wings. Then the male is attracted to the female and follows her tirelessly and closely, performing the so-called "Termiten Liebes-Spaziergang." In this manner the imagoes separate into pairs and enter hiding places in order to establish new colonies, usually under pieces of decaying wood, in holes and crevices in wood, or directly in the earth.

FIG. 1.

In order to observe the starting of a new colony, many new couples were captured in glass tubes, arranged as shown in fig. 1.

The bottom of a test tube, 2 by 16 centimeters, is bored with a capillary pore, and a piece of absorbent cotton, *a*, is inserted. Then a proper quantity of crushed clay, *b*, is placed in the tube to serve as the abode of the future colony; upon this layer pieces of soft wood or cotton, *a*, are laid for food. A male and a female that have recently flown from the nest are now placed in the tube, which is tightly corked and put in a dark place.

In order to keep captive termites in a healthy condition, it is absolutely necessary to give them proper humidity. This is done by placing the end of the tube in water, thus allowing the absorbent cotton to draw a sufficient amount of water through the pore. As a result of these investigations, the following facts were determined:

1. During the first stage of colonization both the male and the female are active. They forage for themselves and are equally important in establishing the new colony and in rearing the first brood of young.
2. Egg laying in a newly established colony begins from five to thirteen days after the swarming.

TABLE II.—*Time between swarming and egg laying.*

RECORDS FOR 1915.

| Days after swarming. | Cases. |
|---|---|
| 5 | 3 |
| 6 | 8 |
| 7 | 10 |
| 8 | 5 |
| 9 | 6 |
| 10 | 5 |
| 11 | 3 |
| 12 | 2 |
| 13 | 3 |

TABLE II.—*Time between swarming and egg laying*—Continued.

RECORDS FOR 1916.

| Days after swarming. | Cases. |
|---|---|
| 5 | 9 |
| 6 | 3 |
| 7 | 7 |
| 8 | 8 |
| 9 | 9 |
| 10 | 3 |
| 12 | 2 |

3. The rate of egg laying is not rapid in the first batch, one to four eggs being laid on one day.
4. Eggs hatch out in from twenty-four to thirty-two days after they are laid.
5. After five months of captivity, the nests in two of the tubes were opened. In these there were no unhatched eggs; the king and the queen, which still retained the normal form of the imago, ran actively, in company with rather small individuals of the worker type and soldiers. The number of individuals in each nest agreed well; one contained twenty-two individuals of the worker type and two soldiers, the other, twenty individuals of the worker type and three soldiers. These facts clearly show that about twenty-five eggs compose the first batch in a newly established colony, and that no more eggs are laid until the eggs of the first brood are all hatched.
6. In the first brood the soldiers are few in comparison with individuals of the worker type, about 10 per cent of the number of the latter being soldiers.
7. Soldiers hatch from the eggs that are laid by true royal females.[2]

SITUATION OF THE NEST

*Coptotermes formosanus* does not construct a large mound as do some species in the Tropics. Usually it makes its nest in the ground at a depth of from 6 to 10 feet (1.82 to 3.04 meters). Very often the nest is made at the junction of rafters of buildings or in the inner part of infested timbers, in wooden boxes or cabinets, or in the interspaces in walls. Generally the nest is round and honeycombed, and in the center there is a small, slitlike royal chamber (Plate II; Plate III, fig. 2).

The nest consists of a mixture of abdominal excreta and clay or sand, pasted together with a special secretion of the salivary glands. Sometimes it is rigid and compact and seems like a piece of rock. However, it is inflammable and burns rapidly, leaving a small amount of ash.

[2] As it is almost impossible from external characters to draw a fast line between larvæ of royal forms and of workers, nothing at present can be said with regard to the origin of these two forms.

TABLE III.—*The rate of egg laying, Coptotermes formosanus.*

| Date | Eggs. Total. | Eggs. Increase. | Larvæ. Total. | Larvæ. Increase. |
|---|---|---|---|---|
| May 20[a] | | | | |
| May 26 | 3 | 3 | | |
| May 27 | 4 | 1 | | |
| May 28 | 6 | 2 | | |
| May 29 | 7 | 1 | | |
| May 30 | 8 | 1 | | |
| May 31 | 10 | 2 | | |
| June 1 | 10 | | | |
| June 2 | 10 | | | |
| June 3 | 10 | | | |
| June 4 | 10 | | | |
| June 5 | 12 | 2 | | |
| June 6 | 16 | 4 | | |
| June 7 | 16 | | | |
| June 8 | 18 | 2 | | |
| June 9 | 18 | | | |
| June 10 | 18 | | | |
| June 11 | 18 | | | |
| June 12 | 22 | 4 | | |
| June 13 | 22 | | | |
| June 14 | 22 | | | |
| June 15 | 22 | | | |
| June 16 | 22 | | | |
| June 25 | 22 | | | |
| June 26 | 19 | | 3 | 3 |
| June 27 | 17 | | 5 | 2 |
| June 28 | 16 | | 6 | 1 |
| June 29 | 13 | | 9 | 3 |
| June 30 | 13 | | 9 | |
| July 1 | 13 | | 9 | |
| July 2 | 13 | | 9 | |
| July 3 | 12 | | 10 | 1 |
| July 4 | 12 | | 10 | |
| July 5 | 14 | 4 | 12 | 2 |
| July 6 | 12 | 1 | 15 | 3 |
| July 7 | 12 | 4 | 19 | 4 |
| July 8 | 13 | 1 | 19 | |
| July 9 | 13 | | 19 | |
| July 10 | 13 | | 19 | |
| July 11 | 13 | | 19 | |
| July 12 | 12 | | 20 | 1 |
| July 13 | 12 | | 20 | |
| July 14 | 12 | | 20 | |
| July 15 | 11 | | 21 | 1 |

[a] Date of capture.

### DAMAGE TO BUILDINGS AND OTHER MATERIALS

*Coptotermes formosanus* is essentially a wood destroyer and attacks very seriously all sorts of woodwork and wooden structures. Because of its habit of attacking Japanese pine, which is

an important building material, it is classed as a most formidable pest throughout Formosa. Moreover, as the method of attack of this insect is insidious, usually leaving the outer layer of wood intact as a protective covering from sunlight and its natural enemies, so that the damage is always hidden until beyond repair, it is a most dangerous enemy to buildings (Plate IV).

TABLE IV.—*The rate of egg laying, Coptotermes formosanus.*

| Date. | Eggs. | | Larvæ. | |
|---|---|---|---|---|
| | Total. | Increase. | Total. | Increase. |
| May 20[a] | | | | |
| May 25 | 2 | 2 | | |
| May 26 | 5 | 3 | | |
| May 27 | 5 | | | |
| May 28 | 5 | | | |
| May 29 | 6 | 1 | | |
| May 30 | 8 | 2 | | |
| May 31 | 9 | 1 | | |
| June 1 | 11 | 2 | | |
| June 2 | 13 | 2 | | |
| June 3 | 14 | 1 | | |
| June 5 | 14 | | | |
| June 6 | 15 | 1 | | |
| June 7 | 15 | | | |
| June 8 | 16 | 1 | | |
| June 11 | 16 | | | |
| June 12 | 17 | 1 | | |
| June 14 | 17 | | | |
| June 15 | 18 | 1 | | |
| June 16 | 19 | 1 | | |
| June 19 | 20 | 1 | | |
| June 21 | 20 | | | |
| June 22 | 20 | | | |
| June 23 | 20 | | | |
| June 26 | 20 | | | |
| June 27 | 17 | | 3 | 3 |
| June 28 | 16 | | 4 | 1 |
| June 29 | 15 | | 5 | 1 |
| June 30 | 14 | | 6 | 1 |
| July 3 | 10 | | 10 | 4 |
| July 5 | 6 | | 14 | 4 |
| July 7 | 6 | | 14 | |
| July 8 | 4 | | 16 | 2 |
| July 10 | 4 | | 16 | |
| July 11 | 3 | | 17 | 1 |
| July 12 | 3 | | 17 | |
| July 13 | 0 | | 20 | 3 |

[a] Date of capture.

TABLE V.—*Incubation period of eggs of Coptotermes formosanus.*

| Days. | Cases. |
|---|---|
| RECORDS FOR 1915. | |
| 25 | 1 |
| 26 | 1 |
| 27 | 2 |
| 30 | 1 |
| RECORDS FOR 1916. | |
| 24 | 1 |
| 26 | 4 |
| 27 | 7 |
| 28 | 5 |
| 29 | 3 |
| 30 | 5 |
| 31 | 5 |
| 32 | 4 |

In infesting buildings it generally gains entrance from outdoor colonies. By means of subterranean tunnels of considerable length, which originate from a nest in the ground, it reaches the foundation of a building. At first it attacks foundation timbers, flooring, or supports of porches or steps that are in contact with the ground, and gradually extends its tunnels and excavation into the first, the second, or even the third floor and into the roof, passing through the walls or the interior of timbers (Plate VI, fig. 1).

In cases where the foundation is of stone, concrete, or other impermeable material, it constructs a covered tunnel of a mixture of earth and saliva over the surface and reaches the woodwork. Generally a cross section of this artificial tunnel is semicircular, the diameter being from 5 to 10 millimeters (Plate VII, fig. 1).

*Damage to buildings.*—Ordinary Japanese houses are chiefly constructed of wood and clay, the foundation timbers being laid in contact with the ground. Thus the construction itself is not fitted to prevent the attack of termites. Moreover, Japanese pine and cryptomeria, which are most liable to be attacked by *Coptotermes formosanus*, are the principal building materials. Such being the case, the Japanese people suffer a great deal from the damage when they erect buildings of their own style in Formosa.

As the work of *Coptotermes formosanus* is hidden, it is difficult to detect the presence of the insects or the damage that they are doing. After they have caused the fall of a building, the beams, the rafters, and other important parts of the woodwork are often found to be mere shells, the interior being entirely honeycombed (Plates V and VI).

*Damage to brick walls.*—There are several records in Formosa of modern brick buildings having been infested by *Coptotermes formosanus*. It is absolutely impossible for it to attack brick itself; but, according to my actual observation, the mortar which is used as a cementing material for bricks is subject to attack.

In building a thick brick wall the following method is adopted: The face bricks are laid upon a bed of mortar; the mortar, in a semifluid condition, is then poured into the space between the face bricks; the bricks are then pushed rapidly, horizontally for a short distance, into their position; a certain amount of the mortar is thus displaced; this rises in the side joints and completely fills all the interstices; should the mortar not rise to the top of the joints, the vacant spaces are filled up, when the next course is larried.

All the interstices between the bricks would be completely filled, if the bedding could be carried on theoretically; but this is practically impossible, so that there are almost sure to be voids in brick walls. Under such conditions, termites prefer to pass through brick walls, if they have a chance to permeate them, rather than to excavate ordinary walls; because the voids are always in a favorable condition for their life, being protected from the sunlight and containing a proper amount of moisture.

There are two kinds of mortar used for constructional work; namely, cement mortar and lime mortar. The former is composed of sand and Portland cement (the ratio of Portland cement to sand is from one to two to one to four), while the latter is composed of moderately hydraulic lime and sand (the ratio of lime to sand is usually one to two).

In Formosa until a comparatively recent date lime mortar was exclusively used for the bedding of bricks. It has been found, however, that *Coptotermes formosanus* easily penetrates brick buildings and causes serious damage (Plate VII). Since the Government has required the use of cement mortar instead of lime mortar there has been no record of damage to brick walls. Therefore, it seems reasonable to conclude that there exists some special relationship between lime and the destructive power of *Coptotermes formosanus*.

The soldier of *Coptotermes formosanus* is provided with a special gland on the forehead, which secretes a milky, acidulous fluid; its excreta and saliva are also acidulous, while those of the worker are alkaline. In the passages perforating the lime

mortar of brick walls vast numbers of soldiers are found. Such being the case, it is said that the soldier of *Coptotermes formosanus* attacks lime mortar by dissolving the lime with the acidulous secretions.

*Damage to railway sleepers.*—*Coptotermes formosanus* attacks railway sleepers as well as buildings. According to a statement of the Bureau of the Formosan Government Railway, the life of an untreated, chestnut sleeper is only two years in Formosa, while in Japan proper it is from eight to ten years.

In the southern part of Formosa another species of termite, *Odontotermes formosanus*, also attacks the sleepers, as shown in Plate VIII, fig. 3. The damage it causes is rather more serious than that caused by *Coptotermes formosanus*. Therefore, in the case of sleepers, it is important to prevent the damage caused by these two species. Usually the length of the spike which is used to fix the rail to a sleeper is a little greater than the depth of the latter, so that its tip always penetrates beyond the bottom of the sleeper, causing some damage to that surface (Plate VIII, fig. 1). This point is most liable to be attacked. As the pests excavate the wooden tissue surrounding the spike (Plate VIII, fig. 2), the latter becomes ineffective. Suppose such damage occurs successively in several sleepers; the results are quite obvious—the rails spread and cause great danger to passing trains.

*Damage to ships.*—One can hardly believe that steamships and launches in the water have been attacked by *Coptotermes formosanus;* but it is an undeniable fact. There are many records of such cases in the harbor of Keelung, Formosa. It happens in this way. In the swarming season, many thousands of winged males and females start from the nests in the vicinity of the shore. Some of them have a chance to fly into the ships moored in the harbor and there start new colonies. The interior of the ship is dark enough to favor the establishment of a nest. Usually the bottom of the ship is constructed of Japanese pine, which is most durable in water; all the timbers contain a favorable amount of water. Thus, all conditions being exceedingly favorable to *Coptotermes formosanus*, the ravages are extended step by step, until the vessel becomes unseaworthy, because of the unexpected destruction of important parts of the woodwork. In such a case extermination of the pests is very difficult. When the Government trawler *Ryokai-maru* was found to be infested, it was purposely sunk in the sea in order to destroy the insects.

Besides the above-mentioned damage, that done to bridges, telegraph poles, books, paper, wood pulp, cotton, and clothing is sometimes very serious.

### PRINCIPAL FOOD OF COPTOTERMES FORMOSANUS

The stem of an exogenous perennial is a complex of structural elements of varied form and function. Of these we may distinguish three main groups: *a*, vessels; *b*, wood cells proper; *c*, medullary tissue. The growing cell of plant tissue consists of cell wall and protoplasm, the living functions depending upon the activity of the latter. However, the above-named three main structural elements of the wood do not contain nitrogenous substance—that is, protoplasm—but mainly consist of the special constituent of the cell wall known as cellulose.

There are, as might be expected, a great many varieties of cellulose, and the term must be taken as denoting a chemical group. Cellulose, taken as a group, presents the following characteristic: A colorless substance, insoluble in all simple solvents; generally but variously resistant to oxidation and hydrolysis; nonnitrogenous, having the empirical constitution characteristic of the carbohydrates. The composition of pure cellulose is represented by the percentage numbers C 44.2, H 6.3, O 49.5, corresponding to the empirical formula $(C_6H_{10}O_5)_x$. It is flexible, slightly elastic, permeable, but only slightly absorbent, and does not readily undergo fermentation. When treated with acid it passes into a starchlike condition, as is evidenced by its turning blue with iodine; and under certain conditions in the living plant it would seem capable of being formed from sugar or of passing into it.

It must be noted, however, that the typical cellulose is not separated from the plant in a pure state, but in admixture or in intimate chemical union with other compounds or groups of compounds. The latter are distinguished by greater reactivity; for example, they readily yield to alkaline hydrolysis, to oxidation, or to the action of the halogens. In the latter is included the very important group of lignified cellulose, or lignocellulose, distinguished by the presence of ketohexene groups in union with the cellulose, and therefore combining directly with the halogens.

Generally, walls of cellulose, fibers, and vessels in the wood acquire mechanical strength or resistance by undergoing a change known as lignification. This consists in their impregnation with a substance known as lignin, forming a compound

cellulose, namely, lignocellulose. Lignin, like cellulose, consists of three elements—carbon, hydrogen, and oxygen—but in different proportions, its percentage composition being C 49, H 6, O 44. Its chemical constitution is as yet unknown. It is harder and more elastic than cellulose, readily permeable by water, but not absorbent. It is more soluble in acids than is cellulose and is recognized by turning deep magenta when treated with phloroglucinol in hydrochloric acid.

As shown in the preceding pages, *Coptotermes formosanus* seriously injures all sorts of woodwork and wood products. However, why it attacks such materials or, in other words, what was the principal food of *Coptotermes formosanus* contained in wood was quite unknown. In order to settle this question the following experiments were made:

*Experiment 1.*—A living worker or soldier of *Coptotermes formosanus* was placed on a microscope slide, and the tip of its abdomen was pressed, the excrement being thus discharged. This was treated with phloroglucinol in hydrochloric acid under a cover glass. The color changed to deep magenta, showing the characteristic reaction of lignin.

*Experiment 2.*—A piece of the nest was treated with the same reagent. It also gave a deep magenta coloration, characteristic of lignin.

*Experiment 3.*—A piece of camphor wood and a nest of *Coptotermes formosanus* made from camphor wood were analyzed.

TABLE VI.—*Composition of camphor wood and of a nest of Coptotermes formosanus. Analyzed by T. Katayama.*

[Numbers give percentages.]

| | Water. | Ash. | Aqueous extract. | Pentosan. | Cellulose. | Noncellulose. |
|---|---|---|---|---|---|---|
| Camphor wood | 11.51 | 1.29 | 4.53 | 13.92 | 48.35 | 20.40 |
| Nest | 11.39 | 17.86 | 4.83 | 6.02 | 12.73 | 47.17 |
| Nest (calculated as a substance with no ash) | 13.87 | 0.00 | 5.88 | 7.33 | 15.50 | 57.42 |

It is quite obvious that the amount of cellulose is the main difference between the constituents of the camphor wood and those of the nest. As there occurs no decrease of noncellulose, it is clear that cellulose has been taken as the food when the camphor wood passed through the alimentary canal; and noncellulose, that is, lignin, which is produced as a decomposed material of lignocellulose by the special function of the alimentary canal, is discharged as the building material of the nest.

*Experiment 4.*—In order to confirm the results obtained in experiment 3, *Coptotermes formosanus* in captivity in the special tube was fed with cotton wool, which is pure cellulose. It was observed that it lives more actively than when soft woods are given as food, perforating and eating the cotton wool.

As a result of the above experiments the following facts were found:

1. The principal food of *Coptotermes formosanus* is cellulose.
2. *Coptotermes formosanus* decomposes lignocellulose into cellulose and noncellulose, namely, lignin, and builds its nest with the latter.
3. Cellulose is the principal constituent of the cell walls of plant tissue. Therefore, almost all sorts of wood are attacked by *Coptotermes formosanus.*
4. Paper, wood pulps, books, and cotton wool are liable to be attacked, because they consist of pure cellulose.
5. According to a statement of Thomas E. Snyder, *Leucotermes flaviceps*, the commonest termite in the United States, also attacks books, wood pulp, pasteboard, and rolls of cloth very seriously. This seems to indicate that cellulose may be the principal food of the majority of termites.

## TERMITE-PROOF BUILDING CONSTRUCTION

Serious damage to the Japanese buildings in Formosa is due to the Japanese timbers that are used as the principal building materials; namely, pine and cryptomeria. They are most liable to damage, because they contain a large amount of cellulose in comparison with other timbers, as shown in Table VII.

TABLE VII.—*The amount of cellulose and noncellulose contained in various timbers.*

| | Cellulose. | Noncellulose. |
|---|---|---|
| | *Per cent.* | *Per cent.* |
| Ebony | 29.19 | 48.08 |
| Oak | 39.47 | 34.30 |
| Teak | 43.12 | 38.16 |
| Mahogany | 49.07 | 27.91 |
| Cryptomeria | 50.29 | 25.13 |
| Pine (heartwood) | 51.39 | 22.69 |
| Pine (spring wood) | 53.33 | 21.77 |

When Japan occupied Formosa, Japanese architects had had no experience in regard to methods of preventing the damage caused by termites. Therefore, they erected buildings there just as in the mother country, paying no attention to the termite. This is another reason for the serious damage, for Japanese buildings are not suited to the Tropics. They rather attract the

termite, since the foundation timbers are laid in contact with the ground.

From the point of view of economy, it is impossible to eliminate such nonresistant timbers from Japanese buildings. Therefore, a discovery of a new method of building construction, by which the attack of the termite can be absolutely prevented, becomes an important problem.

As a result of bitter experience during the last twenty years, the method of constructing buildings and the treatment of nonresistant timbers have been greatly improved. As it is practically proved that the termite-proof building construction that has been recently adopted by the Government of Formosa is somewhat satisfactory, I, having been chiefly concerned with the investigation, wish to explain the method in detail.

*Disinfection of the ground.*—Not only is *Coptotermes formosanus* widely distributed throughout Formosa, but it occupies the whole ground densely; so that, as a first step in erecting a building, it is absolutely necessary, to destroy the pest, to keep the site free from the source of the damage. For this purpose, heavy oil of petroleum, creosote oil, or Termitol (a mixture of heavy oil of petroleum and cresol) is sprinkled over the whole surface of the site, using 1 gallon (about 4 liters) of the fluid to 6 square feet (about 0.6 square meter) of area.

These fluids are nonvolatile at ordinary temperature and insoluble in water. They are effective for a long time, as they remain in the ground unchanged.

*Footings.*—To keep a wooden building free from termites, care should be taken not to use timbers in contact with the ground. To do this, it is necessary to use bricks and concrete in footings, even in the case of a wooden building.

*The termite-proof concrete layer.*—In order to prevent the entering of the termite, it is necessary to disconnect the upper parts of buildings from the soil. After the footings have been completed, a layer of cement concrete about 6 inches (about 15 centimeters) thick is spread over the whole area of the site at ground level, the edges being extended about 3 feet (about 1 meter) beyond the external walls of the building. Along the edges small drains are made, surrounding the whole concrete layer. Then the entire surface of the layer is covered with a thin stratum of cement mortar to fill up all the pores and cracks (Plate IX, fig. 1).

To reach the building, termites must either penetrate the concrete layer or cross the drains from the outside. It is proved,

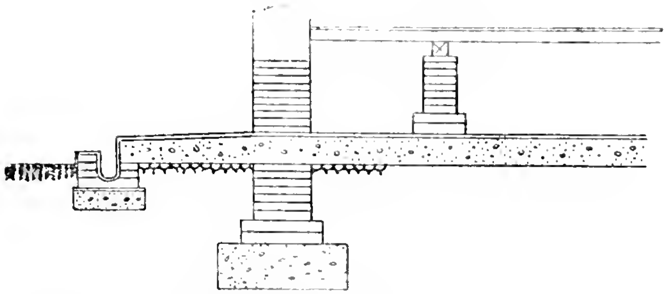


FIG. 2. Detail of termite-proof construction: a continuous layer of cement at ground level.

however, that cement concrete is quite safe against the attack of the termite, while lime concrete is not. Not only is the first method of attack almost impossible, but the second as well, for the drains are so constructed that they catch rain water from the eaves and thus prevent the intrusion of the pest. In the dry season the termite very often crosses the drains; but its covered tunnels can be found at once and it is readily driven out, because the outer parts of the concrete layer extend beyond the external wall and are used as sidewalks.

The aim of constructing a continuous layer of concrete above the ground level is to prevent absolutely the entering of the termite by means of an impermeable barrier. Great care should be taken, therefore, to keep the whole layer perfectly compact, and to avoid the occurrence of cracks and pores. To do so, the entire layer must be spread at the same time, in a continuous, even plane.

One of the practical difficulties of constructing a continuous concrete layer is that it stops construction of all other parts of the building until the concrete is entirely set. To get rid of this difficulty, the methods shown in figs. 3 and 4 are very often adopted. The concrete layer is divided into two or three

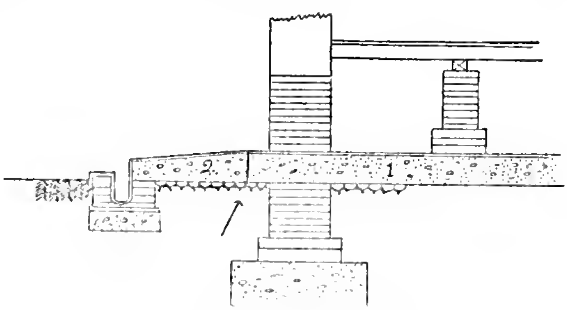



FIG. 3. Detail of termite-proof construction: a layer of cement at ground level laid in two parts.

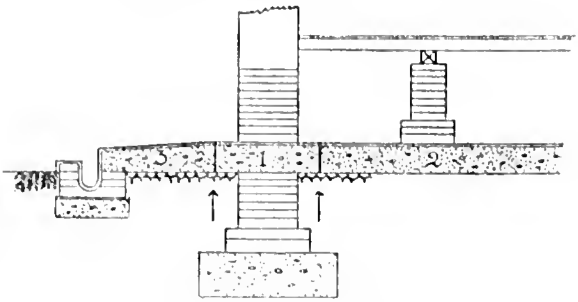



FIG. 4. Detail of termite-proof construction; a layer of cement at ground level laid in three parts.

parts, and each part is spread over the ground at a different time. After all the parts are joined together, the whole surface is covered with cement mortar. At a glance such a concrete layer seems as satisfactory as the ordinary layers. However, junctions between the sections are not tight enough to prevent the intrusion of the termites, and in many cases it was proved that the concrete layer had been penetrated by *Coptotermes formosanus* when it was ill-constructed; that is, with the layer divided into several parts.

Sometimes the architect is required to build the ground floor somewhat higher than the ground level. In such cases the concrete layer should be constructed as shown in fig. 5, and the two layers on different levels connected by another vertical

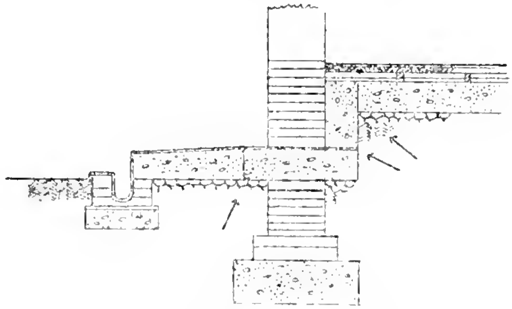


FIG. 5. Detail of termite-proof construction; the protective layer at two levels.

layer. This method is not advisable, however, because of the presence of many junctions, which are liable to be passed through by the termite. If it is necessary to raise one part of the floor, it is better to make two concrete layers separately, instead of joining the two.

*First floor.*—Dark places with a proper quantity of moisture are most favorable for the habitation of *Coptotermes formo-*

*sanus.* It is necessary, therefore, to provide ventilation holes and skylights for inclosed spaces, such as underparts of floors or inner parts of roofs.

In the case of storehouses or other special buildings the termite-proof concrete layer may be directly used as the first floor, as shown in Plate XII, fig. 1; but in ordinary houses the first floor should be raised about 3 feet (about 1 meter) above the concrete layer, by means of brick walls and brick supports. Two methods are adopted for constructing the first floor: *a*, the external parts of the building are entirely surrounded with brick walls about 3 feet (about 1 meter) high, which are provided with square ventilation holes, 2 by 1.2 feet (about 0.6 by 0.4 meter), situated 6 feet (about 2 meters) apart; the floor rests upon square brick supporters (text fig. 2; Plate XIII, figs. 1 to 5); *b*, the floor is placed upon brick arches as shown in Plate XII, fig. 2. Even in wood construction the present method is adopted, all woodwork being placed upon brick supports.

The advantages of this construction are as follows: None of the woodwork is in contact with the ground; the basement of the building is always kept dry and clean; the ample light makes inspection easy; and it is effective in keeping the building free from rats and mice, which are the propagators of the plague.

*Second floor; brick building.*—The second floor is constructed of reënforced concrete just like the concrete layer on the ground level, making a continuous plane. Its edges are extended to the external part of the walls, instead of being partially inserted into the brick walls as shown in Plate XIII, fig. 1. The upper and the lower surfaces of the layer are covered with cement mortar, and all the crevices, even the holes made for gas and water pipes, etc., are carefully filled. Brick walls and partitions on the second floor should be absolutely disconnected from those of the lower floor in order to confine any damage to a limited area. In addition a number of ventilation holes or windows are made through the external walls to expose to the light the inclosed space between the second floor and the ceiling of the lower story (Plate XIII, figs. 2 and 3).

*Second floor; wood construction.*—The distance between the beams of the second floor and the ceiling of the lower story is somewhat extended, and several ventilation holes or windows are made in the external walls to allow sufficient light to enter the interspace (Plate XIII, fig. 5).

*Roofs.*—Both in brick and wooden buildings the inside of the roof is usually dark and contains a lot of timber, thus render-

ing it a favorable habitat for the termite. To get rid of this danger the interspace between the tiebeams and the ceiling is somewhat extended and several windows are made in the external walls as shown in Plate XIII, figs. 4 and 5.

*Brick walls.*—Care should be taken to prevent the entrance of the termite into brick walls, because it is difficult to destroy the insect, which lives in the voids between the bricks. In order to prevent its intrusion, the surface of brick walls should be entirely covered with cement mortar as shown in Plate XIII, fig. 3.

*Tiles.*—Two kinds of tiles are used for roofing Japanese houses; namely, ordinary tile and hanging tile. In laying the former, wet clay is used for bedding; the tiles are embedded in clay one by one and fixed to each other with lime mortar. Clay is never used with the other kind, the tiles being laid on the roof directly and fixed with pieces of wire. It is desirable to use the hanging tile only, for the layer of clay is occasionally used as an abode by the termites when they reach the roof.

*Timbers.*—All the timbers that are used in hidden places are treated with Termol, a special chemical made in the Camphor Bureau of the Government. Both immersion and impregnation are adopted for treating timbers.

*Mortar and concrete.*—It is strictly forbidden to use lime mortar and lime concrete, for lime is attacked by the termite. In constructing Government buildings, cement mortar and cement concrete only are used.

## DEFECTS OF THE TERMITE-PROOF BUILDING CONSTRUCTION

It has been proved that if the concrete layer be kept in a sound condition—in other words, if there are neither cracks nor joints in the layer—the above-described method of construction is entirely satisfactory in preventing the intrusion of the termite from the ground. But there are many records in Formosa of theoretically well-constructed termite-proof buildings being infested by termites, notwithstanding the existence of a perfect concrete layer.

Is there any defect in the present termite-proof building construction, or is there some way by which termites can infest buildings that is not controlled by means of the concrete layer? The answer to these questions is very simple.

As shown on a preceding page the mature males and females of *Coptotermes formosanus* leave the old nest in a swarm early in June. After separating into pairs, each couple establishes a

new colony, raising a number of workers and soldiers. It is possible, therefore, that in the case of a building infested by the winged forms, the damage may be extended year after year, in spite of the existence of the termite-proof concrete layer.

The office of the Nippon Yusen Kaisha at Keelung, Formosa, which was built in 1915 (Plate X, fig. 1), is said to be a good example of the termite-proof construction. Nevertheless, in August, 1916, that is, only one year later, damage caused by termites was found on the second floor (Plate X, fig. 2). At that time there was no damage on the first floor; there was no connection between the nests constructed on the second floor and the ground; the concrete layer on the ground level was perfect, having neither crack nor joint; many hyaline wings, which had been cast by the imagoes of *Coptotermes formosanus*, were found in the building; couples accompanied by young larvæ were found in the brick walls, especially in wood bricks. Such being the case, there could be no doubt that the building had been infested by the winged form, which entered the house in the swarming season.

The concrete layer on the ground level may be strong enough to prevent the pest that starts from the ground, but it is of no use in preventing the intrusion of the winged forms. Certainly, in Formosa, the percentage of the damage to buildings has decreased since the new method of construction was adopted; but the present building construction is not absolutely termite proof, because it does not prevent the entrance of the winged forms.

## TESTS OF THE RELATIVE RESISTANCE OF NATIVE AND EXOTIC WOODS

It is evident that the changes made in several parts of buildings in Formosa are more or less effective in preventing the damage by *Coptotermes formosanus;* but, since it is almost impossible to prevent the entrance of the winged forms, an investigation to discover other methods of prevention becomes necessary.

From an economic point of view it is hard to eliminate nonresistant timbers from building materials, especially in the case of Japanese buildings. Under such conditions the treatment of timbers so as to provide immunity from the attack of the termite is considered more important than the former method; because it is certain that the preventive measures, namely, constructing the concrete layer, etc., become unnecessary if the nature of timbers can be so changed that they are absolutely immune from the attack of the termite.

Certain species of wood are said to be naturally highly resistant to the termite. According to Thomas E. Snyder, forest entomologist of the United States Department of Agriculture, teak (*Tectona grandis*) from Siam and Burma, greenheart (*Nectandra rodiae*) from South America and the West Indies, peroba (several species of *Aspidosperma*) from South America, and mahogany (*Swietena mahogani*) from tropical America seem to be immune from the attack of the North American termites.[3] Hagen also states that teak (*Tectona grandis*) and ironwood (*Sideroxylon*) of India are immune from attack by termites.[4] George P. Ahern, formerly director of the Philippine Bureau of Forestry, states that the following woods are not subject to attack by the *anay*, a native Philippine termite: *Dinglas* (*Eugenia bracteata* Roxb. var. *roxburghii* Duthie), *ipil* (*Intsia bijuga* Gray), *molave* (*Vitex littoralis* Dcne.), and *yacal* (*Hopea plagata* Vidal). In addition to these, *Cedrus deodar* from India, *Cedrus atlantica* from northern Africa, *Callitris glauca* (cypress pine) from Queensland, *Eucalyptus marginata* from Australia, and *Erythrophloeum lim* from Cochin China are reported to be immune from termite attack.

As a first step in the investigation it was necessary to prove whether these so-called immune timbers are really effective in preventing termite attack or not. To do this, forty-five species of native and exotic woods were selected and the test carried on as follows:

*Method of investigation.*—Each timber was cut into small blocks of definite size, 2 by 2 by 15 inches (about 5 by 5 by 38 centimeters); hundreds of these blocks were buried in the infested ground; different kinds of timbers were mingled, care being taken not to group the same species in one place; from time to time all the blocks were dug out for inspection, and after eliminating the infested ones the others were buried again.

*Locality of the experiment stations.*—Tainan, southern part of Formosa; and Matsubase, Kiushiu, Japan proper.

*Materials.*—The woods that were used are enumerated in Table VIII.

*Result of the test at Tainan.*—The ground was infested with *Odontotermes formosanus* (Shiraki), which is very common in the southern part of Formosa. The blocks were buried on November 17, 1912, and the final inspection was made on July 15, 1913.

[3] Bull. U. S. Bur. Ent. 94[2] (1916) 79.

[4] Monogr. Term. 10: 44, 45.

TABLE VIII.—*Scientific and English or local names of woods used in the experiments.*

PHILIPPINE WOODS.

| No. | Scientific name. | English or local name. |
|---|---|---|
| 1 | *Intsia bijuga* O. Ktze. | Ipil. |
| 2 | *Pahudia rhomboidea* Prain | Tindalo. |
| 3 | *Albizzia acle* Merr | Acle. |
| 4 | *Wallaceodendron celebicum* Koord | Banuyo. |
| 5 | *Pterocarpus* sp | Red narra. |
| 6 | *Pterocarpus indicus* Willd | Yellow narra. |
| 7 | *Sindora supa* Merr | Supa. |
| 8 | *Aglaia clarkii* Merr | Tucang-calao. |
| 9 | *Toona calantas* Merr. et Rolfe | Calantas. |
| 10 | *Koordersiodendron pinnatum* Merr | Amuguis. |
| 11 | *Bombycidendron vidalianum* Merr. et Rolfe | Lanutan. |
| 12 | *Pometia pinnata* Forst | Malugay. |
| 13 | *Tarrietia sylvatica* Merr | Dungon. |
| 14 | *Calophyllum inophyllum* Linn | Palo maria. |
| 15 | *Shorea guiso* Blume | Guijo. |
| 16 | *Dipterocarpus grandiflorus* Blanco | Apitong. |
| 17 | *Homalium luzoniense* F.-Vill | Aranga. |
| 18 | *Sonneratia pagatpat* Blanco | Pagatpat. |
| 19 | *Eugenia* sp | Macaasim. |
| 20 | *Xanthostemon verdugonianus* Naves | Mancono. |
| 21 | *Palaquium philippense* C. B. Rob | Malacmalac. |
| 22 | *Illipe betis* Merr | Betis. |
| 23 | *Mimusops elengi* Linn | Bansalaguin. |
| 24 | *Wrightia laniti* Merr | Lanete. |
| 25 | *Vitex parviflora* Juss | Molave. |

WOOD FROM COCHIN CHINA.

| No. | Scientific name. | English or local name. |
|---|---|---|
| 26 | *Erythrophloeum tim* Max | Lim. |

AUSTRALIAN WOODS.

| No. | Scientific name. | English or local name. |
|---|---|---|
| 27 | *Callitris glauca* R. Br. (?) | Cypress pine. |
| 28 | *Eucalyptus saligna* Sm | Blue gum. |
| 29 | *Eucalyptus maculata* Hook | Spotted gum. |
| 30 | *Eucalyptus microcorys* F. Muell | Tallow wood. |
| 31 | *Eucalyptus pilularis* Sm. | Black butt. |
| 32 | *Eucalyptus marginata* Sm | Jarrah. |
| 33 | *Eucalyptus resinifera* Sm | Red mahagony. |
| 34 | *Eucalyptus longifolia* Link et Otto | Wolly butt. |
| 35 | *Eucalyptus acmenioides* Schauer | White mahagony. |
| 36 | *Eucalyptus hemiphloia* F. Muell | Grey box. |
| 37 | *Eucalyptus eugenioides* Sieb | White stringy-bark. |
| 38 | *Eucalyptus propinqua* Deane et Maiden | Grey gum. |
| 39 | *Eucalyptus siderophloia* Benth | Iron bark. |
| 40 | *Syncarpia laurifolia* Tenn | Turpentine. |

TABLE VIII.—*Scientific and English or local names of woods used in the experiments*—Continued.

INDIAN WOODS

| No. | Scientific name. | English or local name. |
|---|---|---|
| 41 | *Tectona grandis* Linn. | Teak. |
| 42 | Unknown | Kayil. |
| | WOOD FROM JAVA. | |
| 43 | Unknown | Jungle wood. |
| | NATIVE WOODS (FROM RIU KIU ISLANDS). | |
| 44 | *Podocarpus macrophylla* Don | Chaaki or hitotsuba. |
| 45 | *Bischofia javanica* Blume | Ikuki or akagi. |

*Result of the test at Matsubase.*—The ground was infested by *Coptotermes formosanus* Shiraki. The experiment station was selected in Japan proper as well as in Formosa, in order to test the effect under different conditions, especially the effect by a different species of termite. The blocks were buried on February 11, 1913, and the first inspection was made on October 8, 1913, after two hundred forty-nine days.

Although the duration of the experiment was nearly the same at Tainan as at Matsubase, the results obtained were slightly different. Thus, in the latter locality, kayil, palo maria, and malacmalac were more seriously attacked; lim, tallow wood, iron bark, grey gum, white mahogany, supa, betis, pagatpat, calantas, malugay, lanete, bansalaguin, lanutan, banuyo, and grey box were less seriously attacked; red narra, guijo, yellow narra, white stringy-bark, acle, amuguis, tucang-calao, tindalo, batitinan, black butt, dungon, mancono, molave, and ipil, which have been attacked by *Odontotermes formosanus*, were immune. These differences seem to be due to the inactivity of the insect effected by somewhat lower temperature than in Formosa, as well as the existence of a smaller number of individuals. In order to get a more satisfactory result, the blocks that were found free from attack were buried again in the same place and left untouched until July 19, 1915.

Twenty-one months after first inspection, all the blocks were dug out. The results are shown in Table XI.

TABLE IX.—*Percentage of the damage to wood blocks by termites at Tainan.*

| Name. | Origin. | Blocks. | | Damage. |
|---|---|---|---|---|
| | | Tested. | Infested. | |
| | | | | *Per cent.* |
| Turpentine | Australia | 3 | 3 | 100.00 |
| Malugay | Philippines | 20 | 18 | 90.00 |
| Lanete | do | 8 | 7 | 87.50 |
| Jungle wood | Java | 21 | 18 | 85.71 |
| Supa | Philippines | 21 | 18 | 85.71 |
| Red narra | do | 55 | 47 | 85.45 |
| Red mahogany | Australia | 24 | 20 | 83.33 |
| Iron bark | do | 29 | 24 | 82.76 |
| Apitong | Philippines | 27 | 22 | 81.88 |
| Lim | Cochin China | 43 | 35 | 81.40 |
| Tallow wood | Australia | 34 | 27 | 79.41 |
| Grey box | do | 39 | 30 | 76.92 |
| Guijo | Philippines | 21 | 15 | 71.43 |
| White stringy-bark | Australia | 27 | 19 | 70.37 |
| Acle | Philippines | 43 | 30 | 69.77 |
| Amuguis | do | 26 | 18 | 69.23 |
| Lanutan | do | 9 | 6 | 66.67 |
| Tucang-calao | do | 29 | 19 | 65.52 |
| Calantas | do | 40 | 26 | 65.00 |
| Wolly butt | Australia | 17 | 11 | 64.71 |
| Chaaki | Riu Kiu | 14 | 9 | 64.29 |
| Ikuki | do | 16 | 10 | 62.50 |
| Yellow narra | Philippines | 46 | 28 | 60.87 |
| Betis | do | 43 | 26 | 60.47 |
| Batitinan | do | 20 | 12 | 60.00 |
| Tindalo | do | 15 | 9 | 60.00 |
| Pagatpat | do | 20 | 12 | 60.00 |
| Black butt | Australia | 19 | 11 | 57.89 |
| White mahogany | do | 16 | 9 | 56.25 |
| Bansalaguin | Philippines | 25 | 14 | 56.00 |
| Jarrah | Australia | 11 | 6 | 54.55 |
| Grey gum | do | 16 | 8 | 50.00 |
| Dungon | Philippines | 44 | 20 | 45.45 |
| Palo maria | do | 28 | 12 | 42.86 |
| Banuyo | do | 51 | 20 | 39.22 |
| Aranga | do | 26 | 10 | 38.46 |
| Malacmalac | do | 25 | 9 | 37.50 |
| Blue gum | Australia | 3 | 1 | 33.33 |
| Kayil | India | 20 | 6 | 30.00 |
| Mancono | Philippines | 25 | 6 | 24.00 |
| Macaasim | do | 38 | 7 | 18.42 |
| Molave | do | 25 | 2 | 8.00 |
| Ipil | do | 25 | 1 | 4.00 |
| Teak | India | 50 | 0 | 0.00 |
| Cypress pine | Australia | 10 | 0 | 0.00 |

TABLE X.—*Percentage of the damage to wood blocks by termites at Matsubase.*

| Name. | Origin. | Blocks. Tested. | Blocks. Infested. | Damage. |
|---|---|---|---|---|
| | | | | *Per cent.* |
| Jungle wood | Java | 10 | 10 | 100.00 |
| Kayil | India | 10 | 10 | 100.00 |
| Palo maria | Philippines | 9 | 8 | 88.89 |
| Apitong | do | 10 | 8 | 80.00 |
| Jarrah | Australia | 10 | 6 | 60.00 |
| Malacmalac | Philippines | 9 | 5 | 55.56 |
| Lim | Cochin China | 10 | 5 | 50.00 |
| Calantas | Philippines | 10 | 4 | 40.00 |
| Aranga | do | 10 | 3 | 30.00 |
| Malugay | do | 10 | 3 | 30.00 |
| Lanete | do | 4 | 1 | 25.00 |
| Bansalaguin | do | 9 | 1 | 22.23 |
| Lanutan | do | 5 | 1 | 20.00 |
| Iron bark | Australia | 10 | 2 | 20.00 |
| Tallow wood | do | 10 | 2 | 20.00 |
| Grey gum | do | 10 | 2 | 20.00 |
| Macaasim | Philippines | 10 | 2 | 20.00 |
| White mahogany | Australia | 10 | 2 | 20.00 |
| Supa | Philippines | 10 | 1 | 10.00 |
| Betis | do | 10 | 1 | 10.00 |
| Pagatpat | do | 10 | 1 | 10.00 |
| Banuyo | do | 10 | 1 | 10.00 |
| Grey box | Australia | 10 | 1 | 10.00 |
| Red narra | Philippines | 10 | 0 | 0.00 |
| Guijo | do | 10 | 0 | 0.00 |
| Yellow narra | do | 10 | 0 | 0.00 |
| White stringy-bark | Australia | 10 | 0 | 0.00 |
| Acle | Philippines | 10 | 0 | 0.00 |
| Amuguis | do | 5 | 0 | 0.00 |
| Tucang-calao | do | 10 | 0 | 0.00 |
| Tindalo | do | 5 | 0 | 0.00 |
| Batitinan | do | 10 | 0 | 0.00 |
| Black butt | Australia | 10 | 0 | 0.00 |
| Dungon | Philippines | 10 | 0 | 0.00 |
| Mancono | do | 10 | 0 | 0.00 |
| Molave | do | 10 | 0 | 0.00 |
| Ipil | do | 9 | 0 | 0.00 |
| Teak | India | 10 | 0 | 0.00 |
| Cypress | Australia | 5 | 0 | 0.00 |

TABLE XI.—*Wood blocks exposed to termites for twenty-one months.*

| Attacked. | More or less attacked. | | Entirely immune. |
|---|---|---|---|
| Calantas. | Tindalo. | Amuguis. | Molave. |
| Malugay. | Yellow narra. | Tucang-calao. | Ipil. |
| Lanete. | Guijo. | White stringy-bark. | Teak. |
| Bansalaguin. | Acle. | Black butt. | Cypress pine. |
| Lanutan. | Red narra. | Batitinan. | |
| Banuyo. | Dungon. | Mancono. | |

These results agree quite well with those obtained at Tainan, although the Philippine woods molave and ipil have been slightly attacked by *Odontotermes formosanus*. It is a striking fact that teak and cypress pine, which are said to be absolutely immune from termites in the Tropics, are also free from the attack of two species of Formosan termites; namely, *Odontotermes formosanus* and *Coptotermes formosanus*. It seems reasonable, therefore, to conclude that teak and cypress pine are absolutely immune timbers.

The following paragraphs are quoted from Boulger:[5]

Cypress pine; *Callitris glauca* R. Br. (?); family Coniferae. Renowned for its pleasant odor—camphoraceous or sometimes reminding one of sandal-wood—and its great power of resistance to insect pests. Cypress pine is about the last timber that the white ant will attack. Some of the species, the red or black pine in particular, produce very showy timber; in fact, many of the planks are so gorgeous in appearance that care is required in using it for decorative purposes, lest it should have too overpowering an effect. At the same time much of the timber is of a quite, handsome character. The prevailing color of the figure is grown of various shades. It may be readily dressed to a smooth and glossy surface. It is extensively used in buildings liable to be attacked by white ants, for house blocks, linings, and ceilings of houses, and for telegraph poles. It is one of the most luxurious firewoods; it burns well, and in burning emits a delicious fragrance very generally admired. It is chiefly distributed in the drier parts of New South Wales, but some is available in the north coast district of Australia.

Teak; *Tectona grandis* L.; family Verbenaceae. It reaches a height of 80 to 100 feet, diameter 3 to 4 feet, sometimes larger. Trunk straight, leaves large, drooping, and deciduous, simple and opposite, with a dense mat of velvety hairs beneath, varying in size from 19–33 centimeters long, and 13.5–22 centimeters wide, though sprout leaves are much larger.

Color of the timber is light straw-color to a brownish red, when fresh, but darkening on exposure. Some of the teak of the Decan is beautifully veined, streaked and mottled. Teak varies much according to locality and soil, that of Malabar being darker, heavier, and rather stronger, but not so large as that of Burma. Though without shakes on its outer surfaces, teak nearly always has a heartshake, which, owing to a twist in the growth, may often at the top be at right angles to what it is at the butt, thus seriously interfering with conversion, though often little affecting the use of the timber in bulk. In these shakes an excretion of apatite or phosphate of lime consolidates in white masses, which will turn the edge of most tools. Teak splits readily and is easily worked, but it owes its superiority for ship-building over both pine and oak in part to its freedom from any change of form or warping, when once seasoned, even under the extreme climatic variations. In India teak is used for railway sleepers, bridges, buildings and furnitures.

Teak is very fragrant when fresh and resembles rosewood, owing to an oleo-resin which also renders the wood probably the most durable of

[5] Boulger, G. S., Wood.

known timbers, making it obnoxious to termites and keeping off rust from iron in contact with it. Seasoned teak has, however, a very unpleasant smell, which has been compared to that of old shoe-leather. It is distributed in India, Burma, Siam, Ceylon, Java, Sumatra, and Celebes. In the Philippines small plantations occur in the southern islands, especially in Zamboanga district, Basilan Island.

## RELATIONSHIP BETWEEN THE RESISTANCE AND THE PHYSICAL PROPERTIES OF TIMBER

It has been proved that some timbers are more highly resistant to termite attack than others; or, in other words, durability of timber seems to be effected by its physical or chemical properties. Determination of the factor of resistance is highly important in order to discover the preventive measures against termites. Therefore, the relation of the physical properties of timbers to the resistance is considered first.

TABLE XII.—*Relationship between resistance and hardness of various woods.*

| Wood. | Degree of hardness. | Damage. |
|---|---|---|
| | | *Per cent.* |
| Ipil | Hard | 4.00 |
| Molave | do | 8.00 |
| Macaasim | do | 18.42 |
| Mancono | Very hard | 24.00 |
| Aranga | do | 38.46 |
| Banuyo | Moderately hard | 39.22 |
| Palo maria | Hard | 42.86 |
| Dungon | Very hard | 45.45 |
| Bansalaguin | do | 56.00 |
| Tindalo | Hard | 60.00 |
| Batitinan | do | 60.00 |
| Pagatpat | do | 60.00 |
| Betis | Very hard | 60.47 |
| Yellow narra | Moderately hard | 60.87 |
| Calantas | Soft | 65.00 |
| Tucang-calao | Hard | 65.52 |
| Amuguis | do | 69.23 |
| Acle | do | 69.77 |
| Guijo | do | 71.43 |
| Red narra | Moderately hard | 85.45 |
| Supa | Hard | 85.71 |
| Malugay | do | 90.00 |

Tables XIII and XIV are based mainly on the work of Gardner.[6] The result of the test obtained at Tainan is adopted in the tables to indicate the percentage of the damage.

[6] Bull. Philip. Bur. Forest. 4 (1907).

TABLE XIII.—*Relationship between resistance and weight of various woods.*

| Wood. | Degree of weight. | Damage. |
|---|---|---|
| | | *Per cent.* |
| Ipil | Heavy | 4.00 |
| Molave | do | 8.00 |
| Macaasim | do | 18.12 |
| Mancono | Very heavy | 21.00 |
| Aranga | Heavy | 38.46 |
| Banuyo | Moderately heavy | 39.22 |
| Palo maria | do | 42.86 |
| Dungon | Heavy | 45.45 |
| Bansalaguin | do | 56.00 |
| Batitinan | do | 60.00 |
| Pagatpat | do | 60.00 |
| Tindalo | do | 60.00 |
| Betis | do | 60.47 |
| Yellow narra | Moderately heavy | 60.87 |
| Calantas | Light | 65.00 |
| Amuguis | Heavy | 69.23 |
| Acle | do | 69.77 |
| Guijo | do | 71.43 |
| Apitong | do | 81.88 |
| Red narra | do | 85.45 |
| Lanete | do | 87.50 |
| Malugay | do | 90.00 |

TABLE XIV.—*The weights of woods of various specific gravities.*

| | Specific gravity. | Per cubic meter. | Per cubic foot. |
|---|---|---|---|
| | | *Kilos.* | *Lbs.* |
| Very heavy | 90 or + | 900 or + | 56 or + |
| Heavy | 70 to 90 | 700 to 900 | 44 to 56 |
| Moderately heavy | 50 to 70 | 500 to 700 | 31 to 44 |
| Light | 50 or — | 500 or — | 31 or — |

As shown in Table XII, mancono and aranga, which are included in the group "very hard," are more seriously attacked than ipil, molave, and macaasim of the group "hard;" banuyo is less attacked than harder woods, such as palo maria, tindalo, etc.; calantas, a soft wood, is also less attacked than tucangcalao, amuguis, acle, etc., which belong to the group "hard."

Table XIII shows that ipil, molave, and macaasim, which are included in the group "heavy," are less attacked than very heavy mancono; that dungon, bansalaguin, batitinan, etc., are more seriously attacked than banuyo and palo maria of the group "moderately heavy;" and that amuguis, acle, guijo, etc., are also more seriously attacked than calantas, a light wood.

Thus the durability or resistance of timbers to the attack of termites is not effected by hardness or weight; that is, the immunity of timbers is not due to their physical properties.

## RELATIONSHIP BETWEEN THE RESISTANCE AND THE CHEMICAL PROPERTIES OF TIMBER

Snyder[7] states that the immunity or relative resistance of ironwood is not due to hardness—since Asiatic termites attack the hardest wood, lignum-vitæ—but to the presence in the wood of a substance (oils or alkaloids) repellent or distasteful to termites. He also states that the presence of tyloses or of gums may be factors in determining the durability and resistance of hardwood species. It has been proved that the physical properties of woods are not the real factor of resistance as suggested by that author. However, another suggestion of Snyder, that the presence of certain chemical substances in woods is the true factor, is somewhat dubious. As he gives no data in detail, it is hard to understand what are the principal ingredients and how they act in preventing the damage.

In order to determine the relationship between the resistance and the chemical properties of woods, I made the following investigation:

The quantity of ash and benzene extract in the above-mentioned woods was measured and compared with the percentage of damage obtained at Tainan.

*Sampling.*—A block of wood is cut along the three planes crossed at right angles, and the sawdust is collected. By the diagonal method reduction of the amount of the sample is made repeatedly, until about 20 grams of the sawdust are obtained. This sample is exposed for one hour in an air bath at 105° to 110° C. Then it is kept in a desiccator as a representative sample.

*Method of estimation of ash.*—A 1-gram sample is heated to redness in a platinum crucible over a Bunsen burner, and the incombustible substances are brought to a constant weight.

*Method of estimation of benzene extract.*—To estimate the benzene extract 5.00 grams of the sample are put into a Soxhlet apparatus and extracted with pure benzene for from six to ten hours. The benzene is driven off on a water bath, and afterwards the container is heated in an air bath at 120° C. to a constant weight. All determinations are made in duplicate.

[7] Bull. U. S. Bur. Ent. 94 (1916) 79, 80.

TABLE XV.—*Amount of ash and benzene extract in various woods.*

| Name of wood. | Origin. | Damage. | Ash. | Benzene extract. |
|---|---|---|---|---|
| | | *Per cent.* | *Per cent.* | *Per cent.* |
| Cypress pine | Australia | 0.00 | 1.51 | 5.98 |
| Teak | India | 0.00 | 2.96 | 6.22 |
| Ipil | Philippines | 4.00 | 1.37 | 0.68 |
| Molave | do | 8.00 | 2.97 | 2.60 |
| Macaasim | do | 18.42 | 1.54 | 2.31 |
| Mancono | do | 24.00 | 2.58 | 0.004 |
| Kayil | India | 30.00 | 2.00 | 3.80 |
| Malacmalac | Philippines | 37.50 | 1.43 | 3.37 |
| Aranga | do | 38.46 | 4.25 | 0.01 |
| Banugo | do | 39.22 | 0.75 | 0.15 |
| Palo maria | do | 42.86 | 2.65 | 2.93 |
| Dungon | do | 45.45 | 5.26 | 0.79 |
| Grey gum | Australia | 50.00 | 0.74 | 0.53 |
| Jarrah | do | 54.55 | 1.00 | 2.65 |
| Bansalaguin | Philippines | 56.00 | 1.77 | 0.05 |
| White mahogany | Australia | 56.25 | 0.33 | 0.55 |
| Black butt | do | 57.89 | 0.42 | 0.05 |
| Pagatpat | Philippines | 60.00 | 3.74 | 0.27 |
| Tindalo | do | 60.00 | 2.30 | 1.99 |
| Batitinan | do | 60.00 | 6.48 | 2.43 |
| Betis | do | 60.47 | 2.25 | 0.06 |
| Yellow narra | do | 60.87 | 1.87 | 2.23 |
| Ikuki | Riu Kiu | 62.50 | 1.70 | 0.37 |
| Chaaki | do | 64.29 | 1.61 | 0.36 |
| Wolly butt | Australia | 64.71 | 1.05 | 0.14 |
| Calantas | Philippines | 65.00 | 1.82 | 1.50 |
| Tucang-calao | do | 65.52 | 2.44 | 2.19 |
| Lanutan | do | 66.67 | 2.99 | 0.44 |
| Amuguis | do | 69.23 | 2.41 | 1.79 |
| Acle | do | 69.77 | 1.31 | 1.51 |
| White stringy-bark | Australia | 70.37 | 0.62 | 0.16 |
| Guijo | Philippines | 71.43 | 1.96 | 1.13 |
| Grey box | Australia | 76.92 | 0.78 | 0.40 |
| Tallow wood | do | 79.41 | 0.51 | 1.68 |
| Lim | Cochin China | 81.40 | 0.23 | 2.22 |
| Apitong | Philippines | 82.76 | 0.77 | 0.004 |
| Red mahogany | Australia | 83.33 | 0.58 | 0.26 |
| Red narra | Philippines | 85.45 | 1.36 | 3.80 |
| Supa | do | 85.71 | 1.56 | 0.80 |
| Jungle wood | Java | 85.71 | 3.07 | 0.11 |
| Lanete | Philippines | 87.50 | 2.04 | 0.002 |
| Malugay | do | 90.00 | 3.13 | 0.13 |

From Table XV it is evident that no special relationship exists between the resistance and the amount of ash and benzene extract. It is rather striking, however, that the percentage of benzene extract contained in cypress pine and teak, which are absolutely immune from the attack, is extraordinarily high. As it is probable that some organic compounds extracted by benzene are distasteful or repellent to termites, determination of the

chemical properties of these extracts has been made as shown in the following pages.

## THE VOLATILE CONSTITUENTS OF CYPRESS PINE

[The following is based mainly on the work by Kinzo Kafuku, former expert chemist of the Government Institute of Science, Formosa.]

A block of cypress pine weighing 36 kilograms is sliced into thin pieces and placed in a large extractor. After extracting for three days continuously, using 90 per cent alcohol, the alcohol is distilled off, and by means of steam distillation the light and the heavy oils are separated from the resinous substances. Upon cooling delicate needle-shaped crystals appear in the heavy oil. Because of their viscous nature, it is very hard to separate the oils from the water by filtration. Therefore, a proper quantity of ether is added in order to transfer the oils to that layer. After separating the layer of ether with a separatory funnel, ether is eliminated by distillation. Then that which remains is heated under low pressure (30 millimeters), and the ether and water are completely driven off. Thus, 375 grams of the sample (1.04 per cent per kilogram of wood) are obtained. Alcohol, instead of benzene, is used as a solvent because it is more economical and has the same power of extraction in this case.

*Crude oil.*—The crude oil extracted from cypress pine is a viscous substance having a greenish brown tinge and a slight acid reaction; it evaporates at 280° C. under ordinary pressure.

TABLE XVI.—*Properties of the crude oil from cypress pine.*

| | |
|---|---|
| Specific gravity (at 17° C.) | 1.002 |
| Refractive index (at 20° C.) | 1.5084 |
| Optical rotatory power ($[\alpha]^D$ in 20 per cent ethyl alcohol) (degrees) | +18 |
| Acid value | 18.13 |
| Ester value | 51.50 |
| Ester value after acetylation | 196.1 |

These ester values indicate the presence of about 90 per cent of alcohol ($C_{15}H_{26}O$).

The result of the elemental analysis is as follows:

0.1863 gram crude oil gave 0.5473 gram $CO_2$ and 0.1849 gram $H_2O$.

| | Required for $C_{15}H_{26}O$. Per cent. | Found. Per cent. |
|---|---|---|
| C | 81.08 | 80.12 |
| H | 11.71 | 11.11 |

Besides this, the existence of the ester (15 per cent) and of phenol (10 per cent) is also proved. But as the percentages

of these two are not high, it is probable that the main part of the oil consists of a group of sesquiterpene alcohols.

*Fractionation of the neutral oil.*—Two hundred grams of 50 per cent aqueous solution of sodium hydroxide are added to 100 grams of the crude oil, and the mixture is shaken for two hours. Then ether is added in order to separate the oil from the solution. Eliminating the ether, the neutral oil is obtained free from acid and phenol. About 80 per cent of the crude oil is neutral oil having the following properties:

TABLE XVII.—*Properties of the neutral oil from cypress pine.*

| | |
|---|---|
| Specific gravity (at 10°C.) | 1.009 |
| Refractive index (at 19°C.) | 1.5090 |
| Optical rotatory power ($[\alpha]^D$ in 20 per cent ethyl alcohol) (degrees) | +19.5 |
| Ester value | 33.75 |
| Ester value after acetylation | 162.5 |

These ester values indicate the presence of about 56 per cent of alcohol ($C_{15}H_{26}O$) in the neutral oil.

This oil evaporates at 120° C. under reduced pressure (4 millimeters), thus indicating more clearly the presence of sesquiterpene alcohol.

The result of a fractional distillation of a 50-gram sample of the neutral oil is shown in Table XVIII.

TABLE XVIII.—*Fractions obtained from the neutral oil of cypress pine.*

| Distilling point; pressure, 4 mm. | Yield. | |
|---|---|---|
| °*C.* | *Grams.* | *Per cent.* |
| 115 to 119 | 11 | 18.0 |
| 119 to 125 | 23 | 37.7 |
| 125 to 135 | 2 | 3.3 |
| 135 to 145 | 7 | 11.5 |
| 145 to 170 | 6 | 9.8 |

The fractional distillation is repeated three times; and, finally, the results recorded in Table XIX are obtained.

TABLE XIX.—*Final fractions from the neutral oil of cypress pine.*

| Distilling point; pressure, 3.5 mm. | Yield. | Refractive index. | Rotation $[\alpha]$ D |
|---|---|---|---|
| °*C.* | *Grams.* | | *Degrees.* |
| 110 to 115 | 7 | 1.5045 | +10 |
| 115 to 122 | 16 | 1.5066 | +10.5 |
| 122 to 128 | 11 | 1.5082 | +21.1 |
| 128 to 142 | 9 | 1.5095 | +24.6 |
| 142 to 165 | 6 | 1.5128 | +36.4 |

The first fraction is pale green and less viscous, while the second and third are rather sticky, yellowish in color, and gradually crystallize when fed with a piece of the crystals obtained from the crude oil.

It is obvious that the main part of the neutral oil consists of the second and third fractions, the principal ingredient of which is the same substance as that crystallized from the crude oil.

Five grams of the crude oil are placed on the surface of an absorptive porcelain plate. When the oil is entirely absorbed, the crystals are dissolved in absolute alcohol, and the solution is diluted with one-fourth its volume of water and filtered. The precipitate thus obtained is recrystallized from 70 per cent alcohol and dried.

The melting point of these crystals is 91.2° to 91.5° C. An elemental analysis indicates that these crystals are a compound belonging to the sesquiterpene alcohols.

0.0995 gram of crystals gave 0.2926 gram $CO_2$ and 0.1046 gram $H_2O$.

| | Required for $C_{15}H_{26}O$. Per cent. | Found. Per cent. |
|---|---|---|
| C | 81.08 | 80.20 |
| H | 11.71 | 11.66 |

The optical rotatory power of this substance dissolved in chloroform is —30°, approximately that of guajol (—29.8°), which belongs to the sesquiterpene alcohols. Testing many other important chemical reactions, Mr. Kafuku came to the conclusion that the crystal is nothing but guajol.

An elemental analysis of the first fraction of the neutral oil is carried on; and it is proved that the fraction also consists of a sesquiterpene alcohol, although it does not contain the crystal.

0.1194 gram of crystals gave 0.3504 gram $CO_2$ and 0.1206 gram $H_2O$.

| | Required for $C_{15}H_{26}O$. Per cent. | Found. Per cent. |
|---|---|---|
| C | 81.08 | 80.08 |
| H | 11.71 | 11.30 |

*Phenol and acid*.—The neutral oil which is separated from sodium hydroxide solution is washed with an aqueous solution of sodium chloride. The sodium chloride and the sodium hydroxide solutions are mixed; acids and phenols which are contained in this solution are separated by 5 *N* sulphuric acid and extracted three times with ether. The ether solution is treated three times with 5 per cent solution of sodium bicarbonate in order to separate the acids from the phenols. It is estimated

that the crude oil contains 7 per cent phenols and 10.5 per cent of acids. The result of a fractional distillation of the acids is given in Table XX.

TABLE XX.—*Fractional distillation of the acids.*

| Distilling point: pressure, 3 mm. °C. | Yield. Per cent. |
|---|---|
| 115 to 155 | 38 |
| 155 to 175 | 30 |
| Residue | 30 |

These acids seem to belong to the fatty acids. But at present nothing can be said about their chemical properties.

Baker and Smith [8] made an investigation of the phenol, and the name callitrol has been proposed for it. As these authors did not give the data in detail, it is hard to identify this phenol. However, the color reaction briefly stated by them is indicated in the phenol obtained by the above-mentioned method. It is reasonable, therefore, to treat the present phenol as callitrol. The result of a fractional distillation of the phenol is given in Table XXI.

TABLE XXI.—*Fractional distillation of the phenol.*

| Distilling point: pressure, 4 mm. °C. | Yield. Per cent. |
|---|---|
| 125 to 135 | 15 |
| 135 to 155 | 7 |
| 155 to 165 | 48 |
| Residue | 30 |

According to the statement by Mr. Kafuku, the presence of eugenol in the first fraction is undeniable. He states also that the empirical composition of the third fraction approximates $C_{13}H_{28}O_2$.

As shown, the volatile constituent of cypress pine is mainly guajol, a sesquiterpene alcohol, which is said to be highly antiseptic. In order to prove the effect of this oil practically, the crude oil separated from resinous substances was dissolved in alcohol and injected into Japanese pine, which is most liable to the attack of termites. After entirely evaporating the alcohol, the treated blocks were buried in ground infested by *Coptotermes formosanus*. Although the controls, that is, untreated wood specimens, were seriously attacked within only one week, the treated ones were not attacked during one year (Plate XI, fig. 2, *a*, *b*).

[8] Baker, Richard T., and Smith, Henry G., A research on the pines of Australia. Technological Museum, New South Wales (1910) 63.

Such being the case there is no doubt that the volatile constituents of cypress pine are effective in preventing the attack of termites.

SUMMARY

1. Cypress pine contains about 1 per cent of volatile constituents.
2. The volatile constituents are effective in preventing the attack of termites.
3. The principal ingredient of the volatile constituents is guajol, which is said to be highly antiseptic. The oil contains about 60 per cent of guajol.
4. The volatile constituents of cypress pine contain a small amount of unknown acids and phenol. The latter seems to be callitrol.

## THE VOLATILE CONSTITUENTS OF TEAK

In 1887 Romanes [9] made an investigation on the volatile constituents of teak. According to his statement the alcohol extract of teak does not contain volatile oils, but consists mainly of resinous substances. By means of distillation an amber-colored crystal, which he named tectoquinone ($C_{18}H_{16}O_2$), was separated from the resinous substances. It is reported to be soluble in alcohol and melts at 171° C. When it is reduced with zinc powder and acetic acid, a hydrocarbon $C_{14}H_{22}$ is obtained.

In order to test this statement, 600 grams of sliced teak were extracted with alcohol. By means of steam distillation a fine, amber-colored crystal was separated from the extract. It is more or less soluble in water. When it is recrystallized from a dilute alcohol solution, it separates into two parts; one part is pale yellow, while the other is deep yellow. At present nothing can be said about the nature of this crystal nor of the resinous substances, because the materials at hand were insufficient to continue the investigation.

## THE VOLATILE CONSTITUENTS OF FOOCHOW CEDAR AND RANDAI CEDAR

In 1916 at Foochow, South China, I found that the Chinese people were using Foochow cedar (*Cunninghamia sinensis* R. Br.) as the principal building material, claiming that the timber is highly resistant to termite attack. It is certain, however, that the immunity of Foochow cedar is not absolute, because the Chinese houses in Formosa are attacked by the termite, although they are mainly constructed of Foochow cedar.

As a result of inspection of many infested buildings in Foochow I came to the conclusion that the heartwood of Foochow

[9] Proc. Chem. Soc. London (1887) 4-116.

cedar is somewhat resistant, for the damage was less when heartwood was used than when sapwood was used. When freshly cut the heartwood is reddish in color and emits a pleasing fragrance like camphor, while the sapwood is whitish and odorless. It is possible, therefore, that the resistance of the heartwood is due to the presence of some antiseptic chemical. Led by the supposition, an investigation to determine the chemical properties of Foochow cedar was made.

Fresh Foochow cedar, from Foochow (235 pounds, or 106.5+ kilograms), was cut into thin slices and extracted by means of steam distillation. Superheated steam (pressure, 40 pounds, or 18+ kilograms) was passed through the extractor (capacity, 50 pounds, or 22+ kilograms) for five hours, and the vapor was condensed in a copper condenser. The oil layer floating on the water was separated by a separatory funnel. From this 650 grams (4.6 per cent) of viscous, grayish brown oil were obtained. On cooling the oil a large amount of fine, needle-shaped crystals formed. After keeping the oil at 5° C. for twenty-four hours, it was filtered in order to separate the crystals. Crystals thus obtained were placed on an absorptive porcelain plate and entirely freed from oil. One hundred one grams of pure white crystals (nearly 40 per cent of the oil) were obtained. These crystals are soluble in ether, chloroform, petroleum ether, and amyl alcohol and are easily recrystallized from methyl alcohol solution. By means of sublimation under ordinary pressure the substance changes into colorless, delicate crystals, having the appearance of asbestos. The oil separated from the crystals has the properties recorded in Table XXII.

TABLE XXII.—*Properties of oil from Foochow cedar.*

| | |
|---|---|
| Optical rotatory power ($[\alpha]^D$ in 10 per cent benzene solution) (degrees) | +7.74 |
| Refractive index (at 28° C.) | 1.4970 |
| Specific gravity (at 18.5° C.) | 0.9465 |
| Acid value | 0.0 |
| Ester value | 9.37 |
| Ester value after acetylation | 57.20 |

According to the results of an investigation made by K. Kafuku, the present oil contains only 2 per cent of alcohol ($C_{10}H_{18}O$). The presence of nopinene, camphene, and borneol is also proved by that author.[10] Under ordinary pressure it distills at 160° C. Below 310° C. the fractions are colorless,

[10] Report of the termite 6 (1917) 57–91.

while above that temperature they are yellowish and become highly viscous.

The crude crystals separated from the oil were dissolved in absolute alcohol and forty-three parts of water were added. Then the solution was cooled in order to precipitate the crystals. Under atmospheric pressure it was sublimated again, and the pure crystals were obtained.

I. 0.2319 gram of crystals gave 0.6822 gram $CO_2$ and 0.2442 gram $H_2O$.
II. 0.2159 gram of crystals gave 0.6381 gram $CO_2$ and 0.2268 gram $H_2O$.

| | Required for $C_{15}H_{26}O$. Per cent. | Found. Per cent. I. | Found. Per cent. II. |
|---|---|---|---|
| C | 81.08 | 80.23 | 80.61 |
| H | 11.71 | 11.69 | 11.76 |

These percentage numbers agree quite well with those of sesquiterpene alcohol. The molecular weight of the crystals (231 to 234) also approximates that of the sesquiterpene alcohol (222). Such being the case, there is no doubt that the crystalline substance contained in Foochow cedar is a sesquiterpene alcohol.

Mr. K. Kafuku studied this crystal in detail and expressed the view that cedrol, a sesquiterpene alcohol that has been extracted from red cedar (*Juniperus virginiana* L.), is the same substance.

TABLE XXIII.—*Comparison of Foochow cedar crystals with cedrol.*

| | Foochow cedar crystals. | Cedrol. |
|---|---|---|
| Melting point ...°C. | 86 | 86 to 87 |
| Boiling point ...°C. | 292 to 294 | 291 to 294 |
| Optical rotatory power ...degrees.. | [a] +10.9 | [b] +9.5 |

[a] In 10 per cent chloroform solution. [b] In 11.3 per cent chloroform solution.

Cedrol, the principal ingredient of Foochow cedar oil, is not identical with guajol. It is a striking fact, however, that both cypress pine and Foochow cedar, which are said to be highly resistant to the attack of termites, contain antiseptic compounds that belong to the same group, the sesquiterpene alcohols.

Besides Foochow cedar, another species is contained in the genus *Cunninghamia*. A few years ago, Dr. B. Hayata described this species from Formosa, giving it the name *Cunninghamia konishii*. At present it is not known whether it is resistant to the attack of termites or not; but, as it is very closely allied to

Foochow cedar, an investigation of its chemical properties was made.

Some fine, fresh material was forwarded by the authorities of the Bureau of Forestry, from the mountain in Giran. It was treated in the same way as Foochow cedar, being cut into thin pieces and extracted by means of steam distillation. It is rather striking that exactly similar oil and crystals were obtained from Randai cedar and from Foochow cedar. However, the percentage of the oil in Randai cedar, 1.62 per cent, differs slightly from that in Foochow cedar, 4.6 per cent.[11]

## STUDIES ON CAMPHOR GREEN OIL

[The following is a result of the joint work of M. Oshima, naturalist, and Kinzo Kafuku, former expert chemist, of the Government Institute of Science, Formosa.]

As shown in the preceding pages, a sesquiterpene alcohol ($C_{15}H_{26}O$) seems to be one of the chemicals that are effective in preventing the attack of termites. It is highly expensive to import cypress pine or other immune timbers for the sake of building ordinary houses. Moreover, it is almost impossible to get a sufficient quantity of guajol or cedrol for use in conferring immunity upon nonresistant timbers. Under these circumstances the work was extended to discover some home product from which sesquiterpene alcohol could be obtained. As a first step camphor oil was investigated, because the heavy oil of this is greenish and viscous like the oil extracted from cypress

[11] Foochow cedar; *Cunninghamia sinensis* R. Br. Trunk 10 to 15 meters tall, branches whorled. Leaves very densely and alternately arranged, distichous, coriaceous, 3 to 7 centimeters long, 5 to 7 millimeters broad, linear-lanceolate acuminate, slightly serrulate at the margin, polished above, dull below. Male flower 10 to 15 millimeters long, 3 to 4 millimeters broad, yellow. Cone 3 to 4 centimeters long and broad; middle scale 15 to 18 millimeters long and wide; seeds 6 to 7 millimeters long, 5 to 6 millimeters broad, very complanate, surrounded by a small wing.

Randai cedar; *Cunninghamia konishii* Hayata. Trunk tall, branches terete, glabrous. Leaves linear falcate, acute, slightly carinate on the back, lanceolate, 15 millimeters long, 2.5 millimeters broad, slightly obtuse at the apex, slightly serrulate at the margin, coriaceous, slightly glaucous. Cone ovately globose, 20 centimeters long, 15 millimeters broad. Scales rounded. Seeds very small, ovately elliptical, surrounded by a small wing.

The grain of Randai cedar is finer than that of Foochow cedar. When freshly cut it emits a sweet fragrance. The heartwood has a dark reddish color. At present it is hard to find this wood in the market, but the Bureau of Forestry of the Government of Formosa plans to supply it as a building material in Formosa in the near future.

pine and it was thought to be possible to establish the identity of guajol and cedrol.

*Camphor oil.*—Camphor oil is obtained from camphor wood (*Cinnamomum camphora* Nees et Ebermeyer). A trunk of this wood is chopped up and the slices (each piece about 30 to 40 grams) are extracted by means of steam distillation. The mixture of steam and camphor vapor is led to a series of wooden condensers. As soon as it is cooled with running water, crystals of camphor are sublimated under the cover of the condenser and a layer of oil appears floating on the surface of the water. When the oil is cool, the remainder of the camphor is deposited and roughly separated from the oil. These operations are carried on in a camp in the mountains.

The crude camphor oil thus obtained is a yellow or dark yellow fluid and emits the characteristic odor of camphor, thus proving the presence of the crystals of camphor (specific gravity, 0.950 to 0.995 at 15° C.). Under ordinary atmospheric pressure it distills at from 150° to 270° C., yielding *d*-pinene, camphene, cineol, limonene, camphor, and safrol.

In the factory of the Monopoly Bureau of the Government of Formosa, the crude camphor oil is refined and separated into the following fractions:

| | Specific gravity. |
|---|---|
| White oil | 0.87 to 0.91 |
| Mother liquid of camphor | 0.91 to 0.99 |
| Red oil | 0.99 to 1.035 |

It is proved that the residue contains a certain amount of safrol. Therefore, the residue is distilled again under low pressure (200 millimeters) in order to eliminate a fraction which contains a considerable amount of safrol (specific gravity, 1.00 to 1.04). In the beginning of this operation the specific gravity increases gradually. After reaching a constant, it decreases gradually, showing a number less than 1.00. The oil, the specific gravity of which is less than 1.00, is a green or deep blue, viscous fluid and is called camphor green oil (specific gravity, about 0.98; refractive index, about 1.5). Under ordinary atmospheric pressure it distills at 210° to 300° C., leaving 3 per cent of pitch.

*Physical and chemical properties of camphor green oil.*—The samples for the determination of the physical and chemical properties of camphor green oil were supplied by the Monopoly Bureau of the Government.

TABLE XXIV.—*Physical and chemical properties of camphor green oil.*

[Poiseuille's capillary viscosimeter modified by Ostwald was used in the determination of viscosity.]

SAMPLE A.

| | |
|---|---|
| Color | Dark brown. |
| Specific gravity (at 15° C.) | 0.9805 |
| Refractive index (at 17.5° C.) | 1.5035 |
| Optical rotatory power | Unknown. |
| Viscosity (at 20° C.) | 1.38 |
| Fractional distillation (ordinary atmosphere pressure): | Per cent. |
| Below 210 | 1.0 |
| 210 to 230 | 26.0 |
| 230 to 240 | 23.0 |
| 240 to 260 | 25.0 |
| 260 to 300 | 22.0 |
| Residue | 3.0 |

SAMPLE B.

| | |
|---|---|
| Color | Greenish brown. |
| Specific gravity (at 20° C.) | 0.984 |
| Refractive index (at 20° C.) | 1.504 |
| Optical rotatory power | Unknown. |
| Viscosity (at 20° C.) | 1.67 |
| Fractional distillation: | Per cent. |
| Below 210 | 1.0 |
| 210 to 230 | 10.0 |
| 230 to 240 | 26.0 |
| 240 to 260 | 25.0 |
| 260 to 300 | 35.0 |
| Residue | 3.9 |

SAMPLE C.

| | |
|---|---|
| Color | Yellowish brown. |
| Specific gravity (at 20° C.) | 1.00 |
| Refractive index (at 20° C.) | 1.511 |
| Optical rotatory power | +; degree unknown. |
| Viscosity (at 20° C.) | 1.83 |
| Fractional distillation: | Per cent. |
| Below 210 | 0.5 |
| 210 to 230 | 2.0 |
| 230 to 240 | 6.0 |
| 240 to 260 | 42.0 |
| 260 to 300 | 44.0 |
| Residue | 4.0 |

TABLE XXIV.—*Physical and chemical properties of camphor green oil*—Ctd.

SAMPLE D.

| | | |
|---|---|---|
| Color | Greenish brown. | |
| Specific gravity (at 20° C.) | 0.981 | |
| Refractive index (at 20° C.) | 1.503 | |
| Optical rotatory power | +; degree unknown. | |
| Viscosity (at 20° C.) | 1.60 | |
| Fractional distillation: | | Per cent. |
| Below 210 | | 0.7 |
| 210 to 230 | | 14.0 |
| 230 to 240 | | 22.5 |
| 240 to 260 | | 27.0 |
| 260 to 310 | | 32.0 |
| Residue | | 3.0 |

The fractional distillation of sample A has been carried on and the fractions thus obtained have been used in further investigation. It has been distilled under reduced pressure (50 to 55 millimeters) to prevent decomposition.

*Acid and ester value of camphor green oil.*—Two grams of the sample are neutralized with 0.5 *N* alcoholic solution of potassium hydroxide, using phenolphthalein as an indicator. After adding 25 cubic centimeters of the same solution, it is refluxed on a water bath for twenty minutes. Adding 0.5 *N* solution of sulphuric acid, the ester value is estimated. Ester value, 0.66.

Some 0.1 *N* solution of potassium hydroxide is added to 25 grams of the sample, and its acid value is estimated.

| Sample. | Acid value. |
|---|---|
| B | 3.14 |
| C | 5.49 |
| D | 2.58 |

PRINCIPAL CONSTITUENTS OF CAMPHOR GREEN OIL

*Acid and phenol.*—Besides caprylic acid and $C_9H_{16}O_2$, which are known as the constituents of camphor green oil, the presence of the following acids has been newly proved:

Methylene-ether-3,4-dioxybenzene-1-carboxylic acid ($C_8H_6O_4$).
Lauric acid ($C_{12}H_{24}O_2$).
An unknown acid.

The green oil contains about 1.5 per cent of phenols. The composition of this phenolic mixture is highly complicated; at present the presence of eugenol and carvacrol only has been proved.

*Aldehyde and ketone.*—The percentage of aldehyde and ketone

in the camphor green oil is less than 0.04. The presence of the following has been proved:

$\Delta_1$-Menthenone-3 (melting point, 224° C.).
Cumic aldehyde semicarbazone (melting point, 210° C.).
An unknown semicarbazone (melting point, 218° C.).

*Camphor and cineol.*—As a result of the fractional distillation it is proved that camphor green oil still contains camphor (8.1 per cent). The presence of cineol and limonene is a well-known fact.

*Safrol.*—In the fractions distilled at comparatively low temperature crystals of safrol are deposited. It is proved that the oil contains about 30 per cent of safrol.

*Terpene alcohol.*—It is possible to find linarol, garaneol, citroneol, terpineol, *d*-terpineol, and cumic alcohol. The presence of these compounds has not been actually proved, because an important reagent, phenylisocyanate, was not at hand.

*Sesquiterpene and sesquiterpene alcohol.*—It is proved by K. Kafuku that camphor green oil contains about 10 per cent of sesquiterpenes (cadinene, bisabolene, and sesquicamphene) and 25 per cent of sesquiterpene alcohol. He took three fractions (115° to 120°, 120° to 130°, 130° to 140° C.) distilled under reduced pressure (5 millimeters) and redistilled them, adding metallic sodium. The refractive indices are given in Table XXV.

TABLE XXV.—*Refractive indices of the three fractions distilled under reduced pressure.*

| Distilling point. °C. | Refractive index at 18 °C. |
|---|---|
| 120 to 125 | 1.4980 |
| 125 to 130 | 1.4998 |
| 130 to 135 | 1.5032 |
| 135 to 140 | 1.5050 |

Elemental analyses of these fractions have been made by Kafuku, proving that some of the fractions consist entirely of sesquiterpene alcohol as shown in the following:

0.1652 gram of the material gave 0.4920 $CO_2$ and 0.1655 $H_2O$.

| | Required for $C_{15}H_{26}O$ Per cent. | Found. Per cent. |
|---|---|---|
| C | 81.08 | 81.23 |
| H | 11.71 | 11.74 |

This sesquiterpene alcohol is not a crystal like guajol or cedrol, but is a colorless, viscous fluid, sometimes giving a pale green color.

TEST OF THE RESISTANCE OF CAMPHOR GREEN OIL TO TERMITE ATTACK

As supposed in the beginning, camphor green oil really contains sesquiterpene alcohol, which is said to be effective in preventing the attack of termites. In order to prove its effect practically, the following tests were carried on:

*Experiment 1.*—Camphor green oil, roughly fractionated in the Monopoly Bureau, was injected into Japanese pine by means of full process. The blocks (2 by 2 by 15 inches, or about 5 by 5 by 38 centimeters) were buried in ground infested by *Coptotermes formosanus* with several control pieces (untreated pine). The controls were seriously attacked within five to seven days (Plate XI, fig. 2, *a*, *b*), while the treated blocks remained unattacked for about one year (Plate XI, fig. 2, *c*).

It is obvious that camphor green oil is effective in preventing the attack of termites. However, it is very expensive, if the pure oil is used. As shown in Table XXVI, the amount of oil produced in the Monopoly Bureau is not sufficient for treating all the timbers used in Formosa.

TABLE XXVI.—*Camphor green oil produced by the Monopoly Bureau.*

| Year. | Pounds. |
|---|---|
| 1912 | 44,562 |
| 1913 | 23,491 |
| 1914 | 28,397 |

Containing only 1.04 per cent of volatile oil, cypress pine is highly resistant to termites. Foochow cedar, more or less resistant to termites, contains 4.6 per cent of volatile oil. It seems reasonable to expect, therefore, that a small amount of the camphor green oil may be effective in preventing damage. If this is true, we can economize the green oil by using a small amount, instead of a large quantity as in the case of creosoting (5 to 6 gallons per cubic foot, or 18 to 22 liters per 0.028+ cubic meter, of timber).

To use the camphor green oil practically, it is necessary to employ a method of treating timbers at the lowest expense, injecting only a small amount of the oil. In order to determine the limit of the amount of oil that is effective in preventing damage, the following experiment was made:

*Experiment 2.*—Camphor green oil was dissolved in 90 per cent ethyl alcohol, making 1, 2, 3, 5, and 10 per cent solutions. After injecting each solution into Japanese pine (2 by 2 by 15 inches, or about 5 by 5 by 38 centimeters), the alcohol was

evaporated by exposing the blocks to direct sunlight. Thus, a considerable number of blocks of pine containing different amounts of the oil was prepared.

The treated blocks were buried in ground infested by *Coptotermes formosanus*. From time to time they were dug out for inspection, and only the unattacked samples were buried again. This experiment was carried on for nearly two and a half years.

TABLE XXVII.—*Blocks of Japanese pine treated with solutions of camphor green oil.*

[Experiment station, Shakko, near Taihoku. Experiment started August 5, 1914. Blocks inspected March 7, 1915; August 8, 1915; August 28, 1916; and March 24, 1917.]

| Inspected. | Blocks. | | | Damage. |
|---|---|---|---|---|
| | Total. | Infested. | No damage. | Per cent. |
| **1 PER CENT SOLUTION.** | | | | |
| March 7, 1915 | 39 | 39 | 0 | 100 |
| **2 PER CENT SOLUTION.** | | | | |
| March 7, 1915 | 62 | 55 | 7 | 89 |
| August 8, 1915 | 7 | 1 | 6 | 90 |
| August 28, 1916 | 6 | 2 | 4 | 94 |
| March 24, 1917 | 6 | 0 | 6 | 94 |
| **3 PER CENT SOLUTION.** | | | | |
| March 7, 1915 | 67 | 51 | 16 | 76 |
| August 8, 1915 | 16 | 9 | 7 | 90 |
| August 28, 1916 | 7 | 0 | 7 | 90 |
| March 24, 1917 | 7 | 0 | 7 | 90 |
| **5 PER CENT SOLUTION.** | | | | |
| March 7, 1915 | 59 | 11 | 48 | 19 |
| August 8, 1915 | 48 | 15 | 33 | 44 |
| August 28, 1916 | 33 | 3 | 30 | 49 |
| March 24, 1917 | 30 | 2 | 28 | 53 |
| **10 PER CENT SOLUTION.** | | | | |
| March 7, 1915 | 67 | 5 | 62 | 7 |
| August 8, 1915 | 62 | 19 | 43 | 36 |
| August 28, 1916 | 43 | 1 | 42 | 37 |
| March 24, 1917 | 42 | 6 | 36 | 46 |

All the blocks treated with 1 per cent solution were seriously attacked after the lapse of six months. The blocks that were treated with 2 and 3 per cent solutions were also seriously attacked, although a small number of them remained in sound condition for more than two years. By the last inspection it was found that the percentage of damage was very much lower in the blocks treated with 5 per cent and 10 per cent solutions than in those treated with 1 and 3 per cent solutions.

There is no doubt that the camphor green oil itself is effective in preventing the attack of termites. However, when it is used in a too diluted condition it is not absolutely effective, the percentage of damage being inversely proportional to the amount of the oil contained in the solution.

TABLE XXVIII.—*Damage done by termites to Japanese pine blocks treated with different percentages of camphor green oil solution.*

| Length of exposure to termites. | Percentage of damage to blocks containing— | | | | |
|---|---|---|---|---|---|
| | 1 per cent of oil. | 2 per cent of oil. | 3 per cent of oil. | 5 per cent of oil. | 10 per cent of oil. |
| 6 months | 100 | 89 | 76 | 19 | 7 |
| 12 months | ---------- | 90 | 90 | 44 | 36 |
| 24 months | ---------- | 94 | 90 | 49 | 37 |
| 31 months | ---------- | 94 | 90 | 53 | 46 |

The amount of the oil that is effective in preventing the damage may vary with different kinds of timber. I regret that at present I am unable to show the exact amount of oil applicable to different Japanese timbers.

*Experiment 3.*—From an economic point of view, it is desirable to use a minimum amount of the camphor green oil; therefore, the discovery of an economical, efficient solvent in making a dilute solution of the green oil becomes a most important problem. For this purpose I have selected a neutral oil of petroleum produced from the crude oil obtained at Niizu, Japan proper, because it is produced in large quantities at a reasonable price; it is almost colorless, giving no stain to timbers; and it is highly effective in killing the termite.

The following is the result of the test made to determine the exterminating power of various neutral oils. A small amount of oil was placed in a watch glass and a worker of *Coptotermes formosanus* was immersed. Under a dissecting microscope the motion of the insect was observed and the time at which it became motionless was recorded.

TABLE XXIX.—*Duration of life of worker termites in various neutral oils.*

| Name of oil. | Time. | | | | | | | | | | Mean. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *Min.* | *sec.* | *Min.* | *sec.* | *Min.* | *sec.* | *Min.* | *sec.* | *Min.* | *sec.* | *Min.* | *sec.* |
| Kurohana neutral oil | 163 | 00 | 126 | 00 | 150 | 00 | 227 | 00 | 233 | 05 | 179 | 49 |
| Aohana neutral oil | 68 | 00 | 35 | 00 | 61 | 00 | 68 | 00 | ...... | | 58 | 00 |
| Akahana neutral oil | 46 | 00 | 47 | 00 | 46 | 00 | 47 | 00 | 46 | 00 | 46 | 24 |
| Niizu neutral oil | 1 | 15 | 0 | 40 | 0 | 35 | 1 | 15 | 1 | 15 | 1 | 00 |

TABLE XXX.—*Chemical properties of Niizu neutral oil.*

| | |
|---|---|
| Color | Pale yellow. |
| Specific gravity (at 20° C.) | 0.9091 |
| Flashing point (°C.) | 97 |
| Fractional distillation: | Per cent. |
| Below 170 | 0.0 |
| 170 to 270 | 1.0 |
| 270 to 290 | 0.5 |
| 290 to 310 | 2.3 |
| 310 to 330 | 32.0 |
| 330 to 350 | 43.5 |
| Above 350 | 18.5 |
| Residue (weight) | 1.7 |

Five, 10, 15, and 20 per cent solutions of camphor green oil were prepared and were injected into a great number of Japanese pine blocks (2 by 2 by 15 inches, or about 5 by 5 by 38 centimeters) by means of full process (about 5 gallons per cubic foot, or about 18 liters per 0.028 cubic meter, of timber). The treated blocks were buried in ground infested by *Coptotermes formosanus*, at Shakko, near Taihoku. For twenty-four months there was no damage; but after the lapse of thirty-one months, the blocks treated with the 5 per cent solution were slightly infested.

TABLE XXXI.—*Results obtained at the final inspection of Japanese pine blocks injected with solutions of camphor green oil.*

[Experiment started August 5, 1914. Blocks inspected March 7, 1915; August 8, 1915; August 28, 1916; and March 24, 1917.]

| Solution. | Blocks. | | | Damage. |
|---|---|---|---|---|
| | Total. | Infested | No damage. | |
| *Per cent.* | | | | *Per cent.* |
| 5 | 9 | 5 | 4 | 55.55 |
| 10 | 8 | ---- | 8 | 0.00 |
| 15 | 8 | ---- | 8 | 0.00 |
| 20 | 11 | ---- | 11 | 0.00 |

With the control, blocks injected with pure Niizu neutral oil, the results shown in Table XXXII were obtained.

TABLE XXXII.—*Japanese pine blocks injected with pure Niizu neutral oil.*

| | |
|---|---|
| Total blocks | 4 |
| Damaged: | |
| Number | 2 |
| Per cent | 50 |
| Dry rot: | |
| Number | 2 |
| Per cent | 50 |

Notwithstanding the fact that Japanese pine is most liable to the attack of termites, the blocks treated with the neutral oil remained unattacked after the lapse of more than two years. As the controls were attacked by the termite and fungus as well, it is clear that the green oil is an essential factor in preventing the damage. The mixture of Niizu neutral oil and the green oil (10 per cent solution) costs about 5 cents per gallon. Its color is pale yellow, and it gives no stain to timbers; its odor is pleasant, being similar to the characteristic fragrance of camphor; it is nonpoisonous to human beings; it is not volatile under ordinary temperature. Thus, this solution seems satisfactory as a preventive against the attack of termites.

*Volatility of camphor green oil.*—Twenty grams of camphor green oil were weighed in an absorbing vessel with special glass tube. The vessel was connected to a gasometer that was joined to a water pump. Air was pumped into the absorbing vessel and from time to time the amount of the oil was measured. The experiment was carried on for twenty-eight days (at 22° to 28° C.).

TABLE XXXIII.—*Showing volatility of camphor green oil.*

| Volume of air. Liters. | Decreased amount of the oil. Per cent. |
|---|---|
| 250 | 4.11 |
| 500 | 5.37 |
| 750 | 5.90 |
| 1,000 | 6.08 |

Saturated with 1,000 cubic centimeters of the air, the loss of the green oil was estimated to be 6 per cent of the original volume. It is probable, therefore, that the green oil will remain almost permanently, even when used in the open air.

THE RELATIVE EFFECTIVENESS OF PREVENTIVES

In order to prevent the damage caused by termites, a considerable number of wood preservatives has been invented and some of them are largely used in the Tropics. Although it has been proved that camphor green oil is entirely satisfactory in preventing attack by Formosan termites, it has been thought desirable to determine the effectiveness of other chemicals. For this purpose the following ten preservatives, which are among the commonest in the market, were selected for experiments that were carried on at Tainan, Formosa.

*Atlas Preservative A.*—This is a mixture of arsenic and sodium hydroxide. Various chemicals containing arsenic are largely used in the Tropics for exterminating termites.

TABLE XXXIV.—*Chemical composition of Atlas Preservative A.*

| | Per cent. |
|---|---|
| Sodium hydroxide | 42.20 |
| Arsenic | 2.39 |
| Water | 55.41 |

*Wood-preservative A.*—Manufactured by Nippon Paint and Asphalt Co. Ltd. The principal ingredient of this chemical is tobacco extract. It is made in the following way: Tobacco leaves are boiled in a dilute aqueous solution of hydrochloric acid; the solution is filtrated, and a proper amount of sodium salicylide and a solution of resin soap are added to the filtrate.

*Woodilin.*—Imported from the United States. This is a mixture of petroleum heavy oil and wood tar.

TABLE XXXV.—*Characteristics of Woodilin.*

| | | |
|---|---|---|
| Color | Dark brown, with fluorescence. | |
| Specific gravity (at 28°C.) | 0.920 | |
| Flashing point (°C.) | 51 | |
| Fractional distillation: | | Per cent. |
| 110 to 150 | | 0.50 |
| 150 to 210 | | 1.50 |
| 210 to 240 | | 7.50 |
| 240 to 270 | | 10.25 |
| 270 to 300 | | 12.75 |
| Above 300 | | 64.00 |
| Residue (weight) | | 4.88 |

*Woodol.*—Manufactured by Ochiai & Co., in Tokyo. The principal ingredient of this preservative is wood tar.

TABLE XXXVI.—*Characteristics of Woodol.*

| | | |
|---|---|---|
| Color | Dark brown. | |
| Specific gravity (at 28°C.) | 1.018 | |
| Flashing point (°C.) | 52 | |
| Fractional distillation: | | Per cent. |
| Below 150 | | 5.50 |
| 150 to 200 | | 29.50 |
| 200 to 270 | | 8.00 |
| 270 to 300 | | 7.99 |
| Above 300 | | 27.00 |
| Residue (weight) | | 24.38 |

*Carbolin.*—Imported from Germany. The principal ingredient of Carbolin seems to be anthracene oil fractionated from coal tar.

TABLE XXXVII.—*Characteristics of Carbolin.*

| | | |
|---|---|---|
| Color | Dark brown. | |
| Specific gravity (at 28°C.) | 1.122 | |
| Flashing point (°C.) | 123 | |
| Fractional distillation: | | Per cent. |
| 110 to 210 | | 1.00 |
| 210 to 240 | | 6.50 |
| 240 to 270 | | 4.00 |
| Above 270 | | 83.00 |
| Residue (weight) | | 7.50 |
| Crystal of anthracene (weight) | | 0.20 |

*Avenarius Carbolineum.*—Imported from Germany. This is a high fraction of coal tar, mainly containing anthracene oil.

TABLE XXXVIII.—*Characteristics of Avenarius Carbolineum.*

| | | |
|---|---|---|
| Color | Dark brown. | |
| Specific gravity (at 28°C.) | 1.144 | |
| Flashing point (°C.) | 135 | |
| Fractional distillation: | | Per cent. |
| Below 210 | | 1.00 |
| 210 to 240 | | 9.80 |
| 240 to 270 | | 1.50 |
| Above 270 | | 76.00 |
| Residue (weight) | | 12.10 |
| Crystal of anthracene (weight) | | 1.40 |

*Stop-rot.*—Imported from England. This wood preservative contains a large quantity of the heavy oil fractionated from coal tar.

TABLE XXXIX.—*Characteristics of Stop-rot.*

| | | |
|---|---|---|
| Color | Dark brown. | |
| Specific gravity (at 28° C.) | 1.048 | |
| Flashing point (°C.) | 85 | |
| Fractional distillation: | | Per cent. |
| Below 210 | | 15.00 |
| 210 to 240 | | 17.50 |
| 240 to 270 | | 15.00 |
| Above 270 | | 50.50 |
| Residue (weight) | | 2.00 |
| Naphthalene (weight) | | 1.40 |

*Carbolineum Atlas.*—Imported from Germany; a mixture of the anthracene oil and the heavy oil of petroleum.

TABLE XL.—*Characteristics of Carbolineum Atlas.*

| | | |
|---|---|---|
| Color | Dark brown. | |
| Specific gravity (at 28° C.) | 1.122 | |
| Flashing point (°C.) | 128 | |
| Fractional distillation: | | Per cent. |
| 110 to 210 | | 0.50 |
| 210 to 240 | | 1.00 |
| 240 to 270 | | 8.50 |
| Above 270 | | 62.50 |
| Residue (weight) | | 26.10 |
| Crystal of anthracene (weight) | | 0.90 |

*Crepit.*—Manufactured by Nippon Wood-preserving Co. Ltd., in Tokyo; mainly consists of creosote oil.

TABLE XLI.—*Characteristics of Crepit.*

| | | |
|---|---|---|
| Color | Dark brown. | |
| Specific gravity (at 28° C.) | 1.022 | |
| Flashing point (°C.) | 115 | |
| Fractional distillation: | | Per cent. |
| Below 210 | | 16.80 |
| 210 to 240 | | 33.50 |
| 240 to 270 | | 25.00 |
| Above 270 | | 23.30 |
| Residue (weight) | | 4.50 |
| Crystal of anthracene (weight) | | 0.30 |

*Wood-preservative B.*—Manufactured by Nippon Paint and Asphalt Co. Ltd., in Tokyo. This is a mixture of tobacco extract and creosote oil.

METHOD OF EXPERIMENT

Blocks of cryptomeria (2 by 2 by 15 inches) were coated three times with the preservatives and were buried in ground infested by *Odontotermes formosanus* at Tainan. From time

to time they were dug out for inspection. After eliminating the infested blocks, the remainder were buried again. This experiment was carried on for three years, starting on June 24, 1910 (Plate XI, fig. 1). Dates of inspection: July 4, 1911; July 14, 1912; July 14, 1913.

TABLE XLII.—*Result of the experiment.*

| Date of inspection. | Preservative | Blocks. Number. | Infested. | Dry rot. | No damage. | Damage. | Dry rot. |
|---|---|---|---|---|---|---|---|
| | | | | | | *P. ct.* | *P. ct.* |
| July 4, 1911 | Wood-preservative A | 5 | 5 | 0 | 0 | 100.0 | 0 |
| July 14, 1912 | Atlas Preservative A | 7 | 5 | 2 | 0 | 71.4 | 28.6 |
| July 14, 1913 | Woodilin | 4 | 3 | 1 | 0 | 75.0 | 25.0 |
| Do | Woodol | 3 | 3 | 0 | 0 | 100.0 | 0 |
| Do | Carbolin | 5 | 0 | 0 | 5 | 0 | 0 |
| Do | Avenarius Carbolineum | 3 | 1 | 0 | 2 | 33.3 | 0 |
| Do | Stop-rot | 3 | 2 | 0 | 1 | 66.7 | 0 |
| Do | Carbolineum Atlas | 4 | 2 | 0 | 2 | 50.0 | 0 |
| Do | Crepit | 4 | 3 | 1 | 0 | 75.0 | 25.0 |
| Do | Wood-preservative B | 3 | 3 | 0 | 0 | 100.0 | 0 |

As shown in Table XLII, none of the chemicals except Carbolin, Avenarius Carbolineum, Stop-rot, and Carbolineum Atlas is effective in preventing the attack of *Odontotermes formosanus* and fungi as well. It is rather striking that the above-named four chemicals, which are more or less effective, are the high fraction of coal tar, mainly consisting of anthracene oil distilled at a temperature above 270° C. Moreover, the percentage of damage is inversely proportional to the amount of the anthracene oil.

TABLE XLIII.—*Relative values of preventives and the percentage of anthracene oil in each.*

| Preventive. | Damage. | Anthracene oil. |
|---|---|---|
| | *Per cent.* | *Per cent.* |
| Stop-rot | 66.7 | 50.5 |
| Carbolineum Atlas | 50.0 | 62.5 |
| Avenarius Carbolineum | 33.3 | 76.0 |
| Carbolin | 0.0 | 83.0 |

It is evident, therefore, that the anthracene oil is a factor in determining the effectiveness of those chemicals.

Anthracene oil, being a product of destructive distillation of coal tar, emits a characteristic, unpleasant odor. At the same time it is dirty and viscous. Of course, there is no objection to the use of this oil in the field; that is, for the sake of preservation of railway sleepers or electric poles. However, it is not recommended for use in houses, on account of its staining timbers.


SUMMARY

1. In Formosa three species of termite, namely, *Leucotermes flaviceps* Oshima, *Coptotermes formosanus* Shiraki, and *Odontotermes formosanus* (Shiraki), are injurious to wooden structures.
2. A pair of mature individuals of *Coptotermes formosanus* is able to start a new colony.
3. In a newly established colony of *Coptotermes formosanus*, egg laying begins five to thirteen days after swarming.
4. *Coptotermes formosanus* lays from one to four eggs a day.
5. Eggs of *Coptotermes formosanus* hatch in from twenty-four to thirty-two days after they are laid.
6. The soldier of *Coptotermes formosanus* develops from the egg laid by the queen.
7. *Coptotermes formosanus* attacks lime mortar.
8. The principal food of *Coptotermes formosanus* is cellulose.
9. The termite-proof concrete layer is entirely satisfactory in preventing the entrance of termites from the ground.
10. Teak and cypress pine are absolutely immune from the attack of Formosan termites.
11. The resistance of timber is not due to its hardness or weight.
12. The resistance of timber is not due to the inorganic compounds contained in it.
13. The resistance of timber is due to organic compounds that can be extracted by benzene or alcohol.
14. Cypress pine contains "guajol," a sesquiterpene alcohol.
15. Foochow cedar and Randai cedar contain "cedrol," a sesquiterpene alcohol.
16. The resistance of timber is due to the presence of sesquiterpene alcohol.
17. Camphor green oil contains 25 per cent of sesquiterprene alcohol.
18. Camphor green oil is entirely satisfactory as a preventive for buildings.
19. The anthracene oil fractionated from coal tar is effective in preventing the damage of *Odontotermes formosanus*.

# ILLUSTRATIONS

PLATE VII

FIG. 1. A piece of infested brick wall, showing the passage of *Coptotermes formosanus* through lime mortar (horizontal surface of the bricks). White crosses indicate the dissolved passage.

2. A piece of lime mortar which was evidently perforated by *Coptotermes formosanus*.

3. Lateral view of one part of an infested brick wall, showing the void which contains several termites, *Coptotermes formosanus*.

PLATE VIII

FIG. 1. Cross section of a rail fixed to a sleeper, showing the basal surface of the latter broken by the tip of the spike.

2. Cross sections of infested sleepers, passing through the position of the spike.

3. Railway sleepers, of untreated chestnut, upper surface infested by *Odontotermes formosanus*. The positions of the rails are indicated at the middle. Found in the main line near Tainan, Formosa.

PLATE IX

FIG. 1. Scene of the construction of a termite-proof concrete layer over the whole surface of a building site.

2. A model of the termite-proof building construction in Formosa, showing the concrete layer on the ground level.

PLATE X

FIG. 1. Nippon Yusen Kaisha (N. Y. K. Steamship Co.) termite-proof brick building, at Keelung, Formosa.

2. One part of the second floor of the N. Y. K. building shown in fig. 1, showing the damage caused by *Coptotermes formosanus*.

PLATE XI

FIG. 1. The experiment station at Tainan, Formosa. Blocks are dug out.

2. Blocks used in an experiment: *a*, control, untreated pine, after one week; *b*, a block of pine, treated with cypress pine oil, after one year; *c*, a block of pine, treated with camphor green oil, after one year.

PLATE XII

Examples of termite-proof, brick building construction.

PLATE XIII

FIG. 1. Brick building, showing the method of termite-proof building construction adopted until the year 1916.

2. Brick building, showing a new method adopted since the year 1916.

3. Details of fig. 2, showing the construction of the second floor.

4. Wood construction.

5. Details of fig. 4.

TEXT FIGURES

FIG. 1. Test tube for rearing termites: *a*, absorbent cotton; *a'*, food; *b*, clay; *c*, cork.

2. Detail of termite-proof construction; a continuous layer of cement at ground level.

3. Detail of termite-proof construction; a layer of cement at ground level laid in two parts.

4. Detail of termite-proof construction; a layer of cement at ground level laid in three parts.

5. Detail of termite-proof construction; the protective layer at two levels.

167553——5

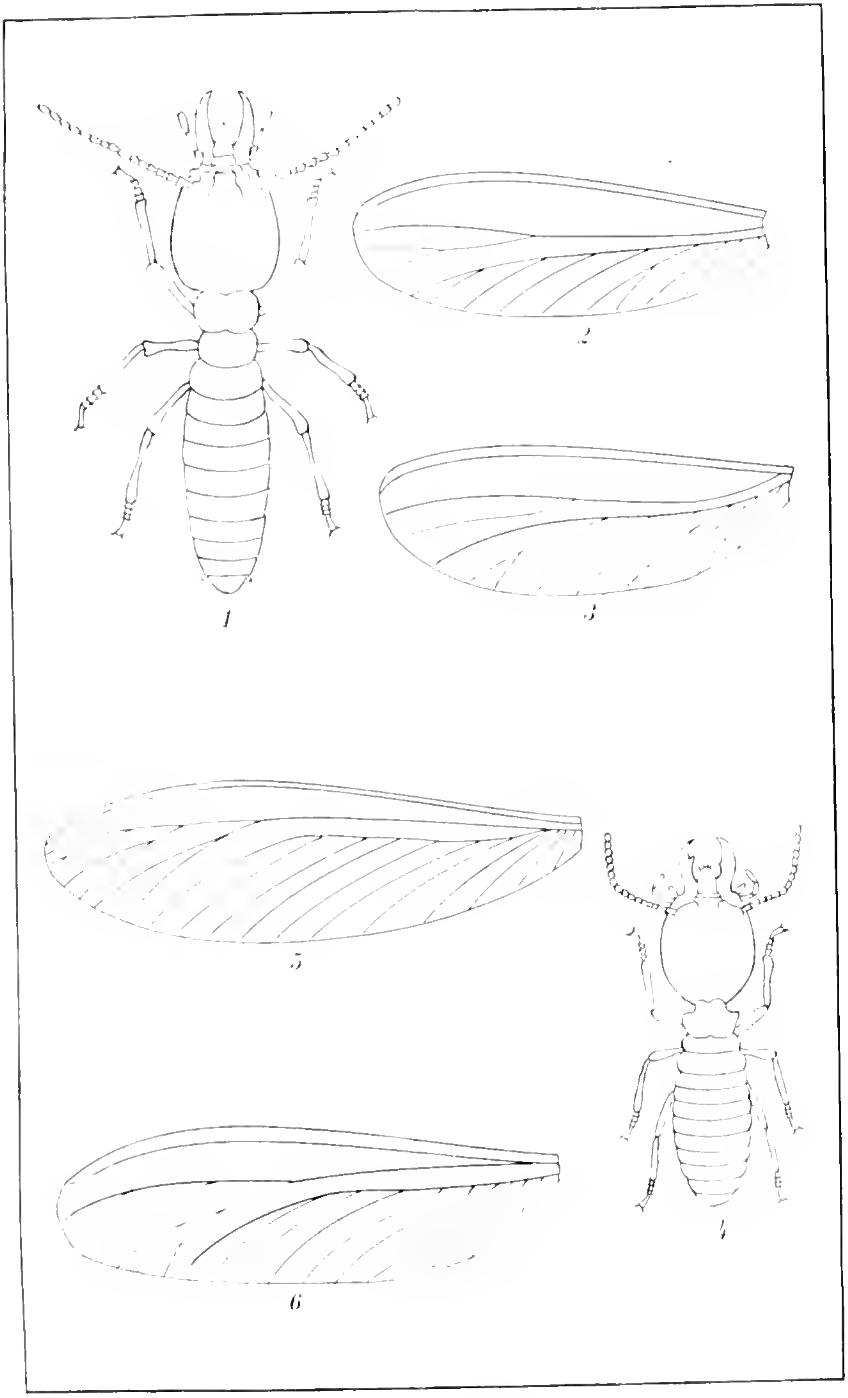



PLATE I. SOLDIERS AND WINGS OF TERMITES.

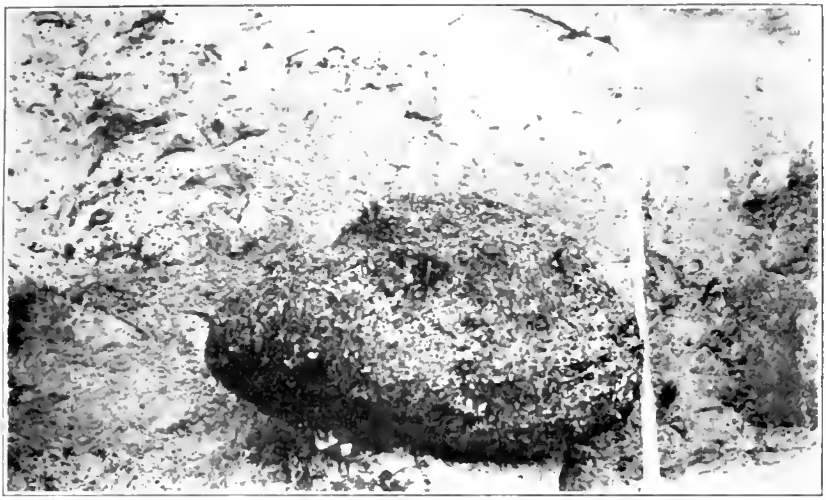


Fig. 1. A termites' nest in its natural position.

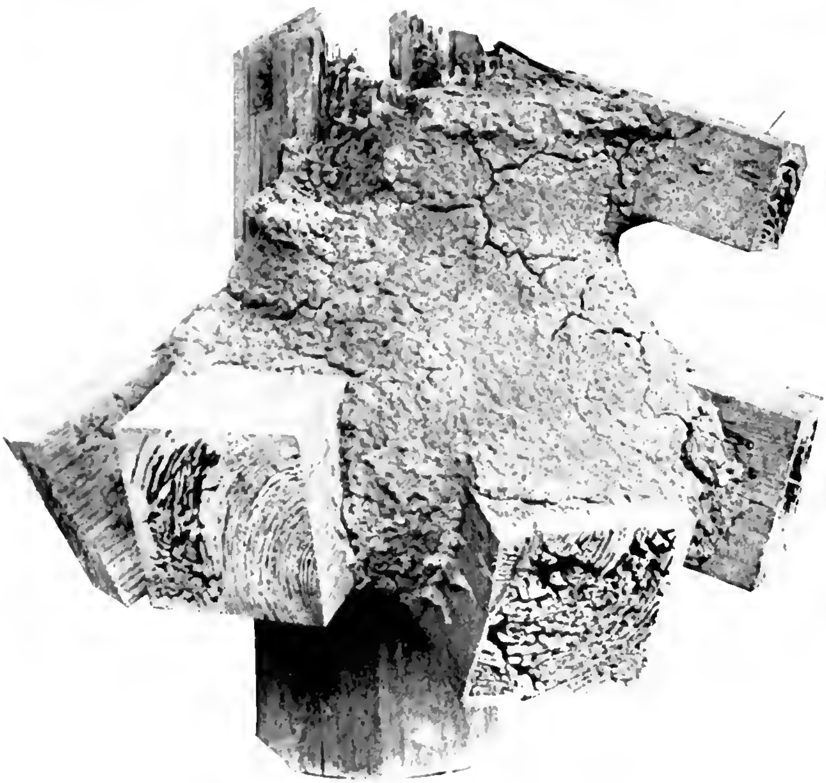


Fig. 2. A termites' nest at the top of a king-post.

PLATE II.

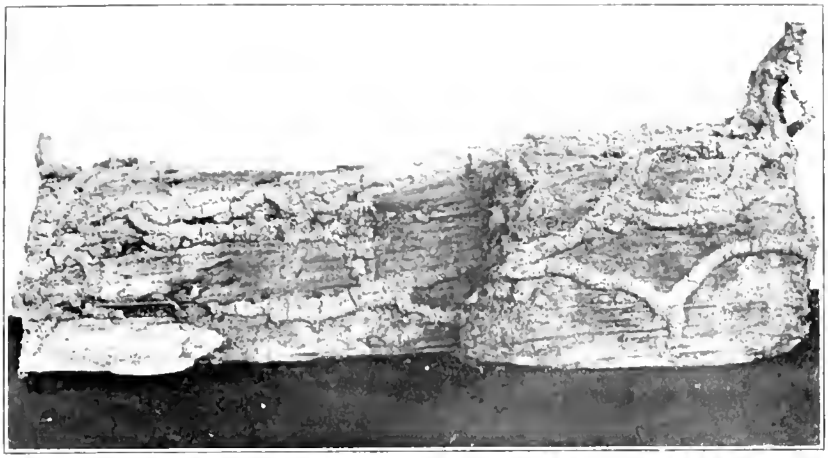


Fig. 1. The covered tunnel built by termites.

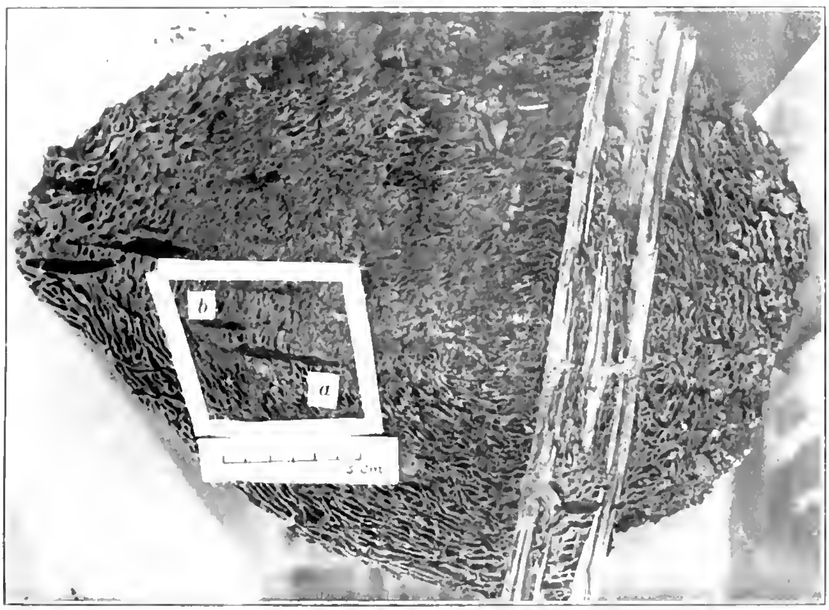



Fig. 2. Cross section of a termites' nest; *a* and *b*, royal chambers.

PLATE III.

Fig. 1. One end of a rafter.

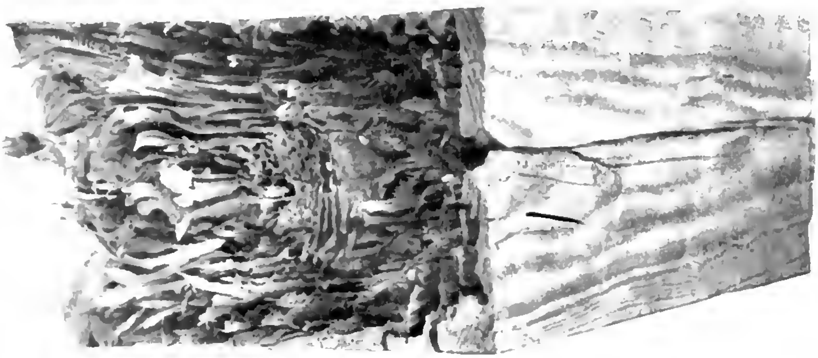


Fig. 2. Part of a tiebeam.

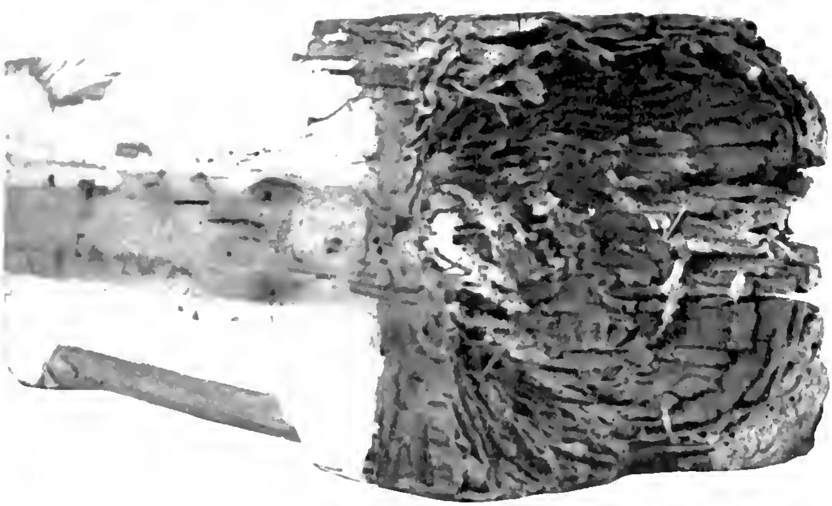


Fig. 3. One end of a pillar.

PLATE IV. DAMAGE DONE BY TERMITES.

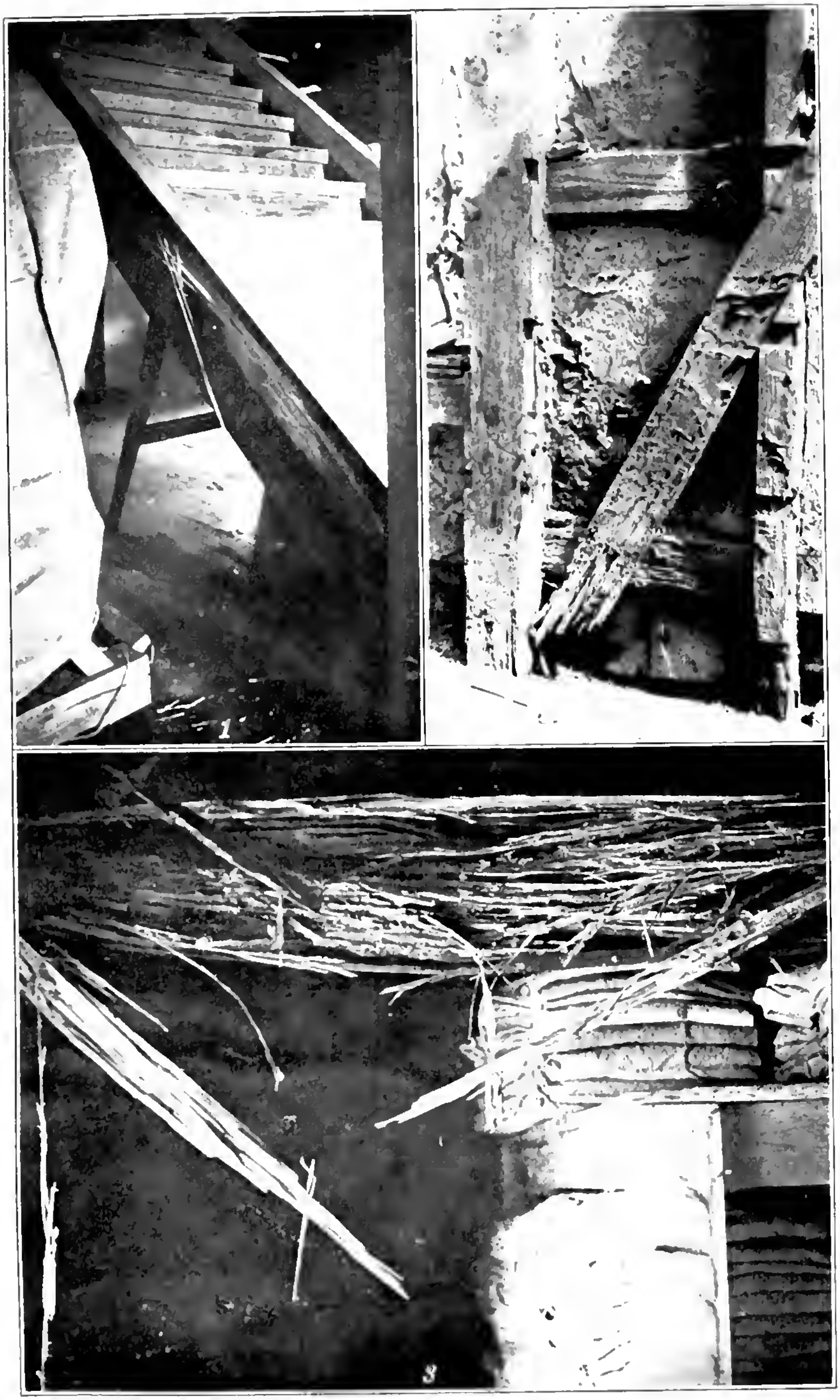


PLATE V. DAMAGE DONE BY TERMITES.

Fig. 1. Pathway of termites in a wall.

Fig. 2. Exterior of a damaged building.

PLATE VI.

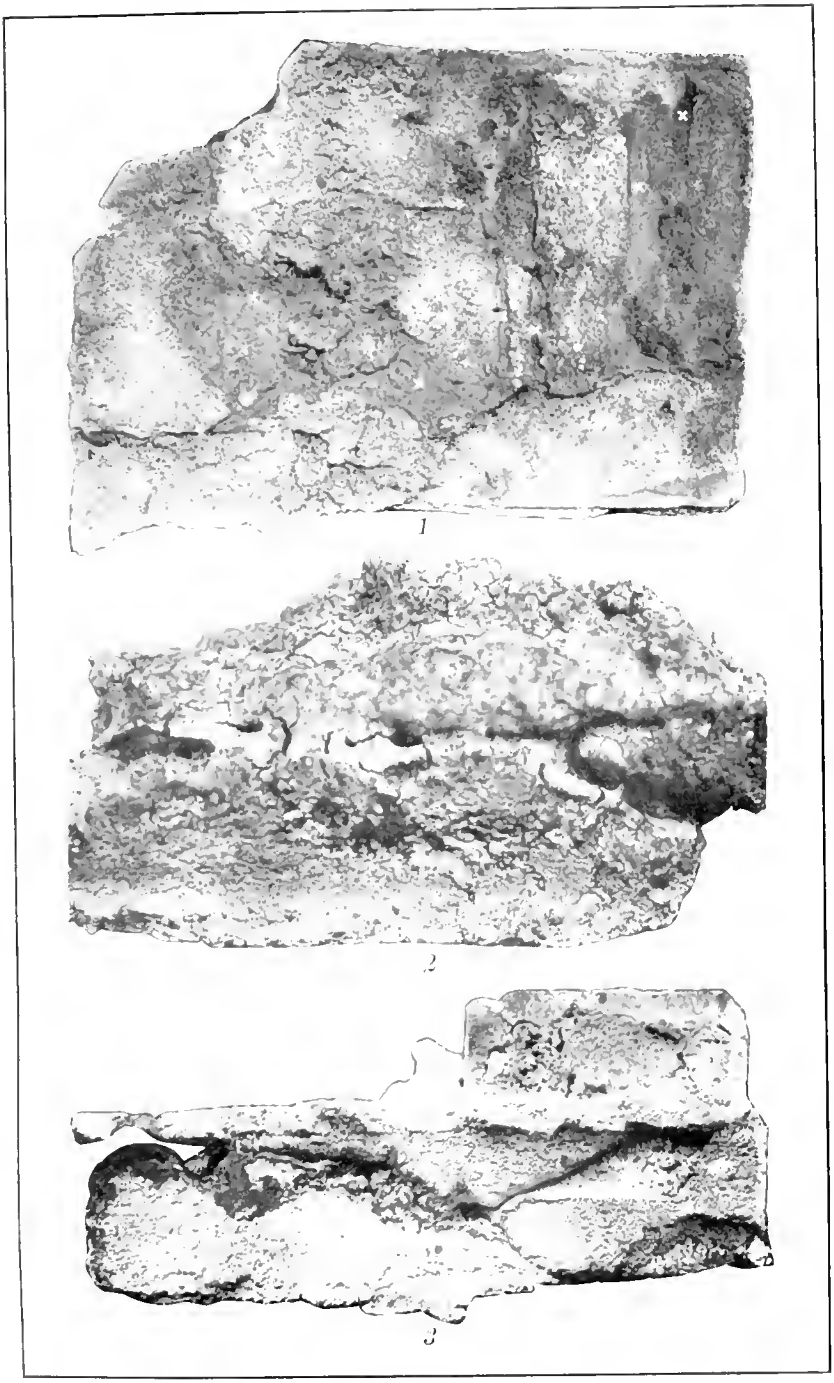


PLATE VII. TERMITES IN BRICK WALLS.

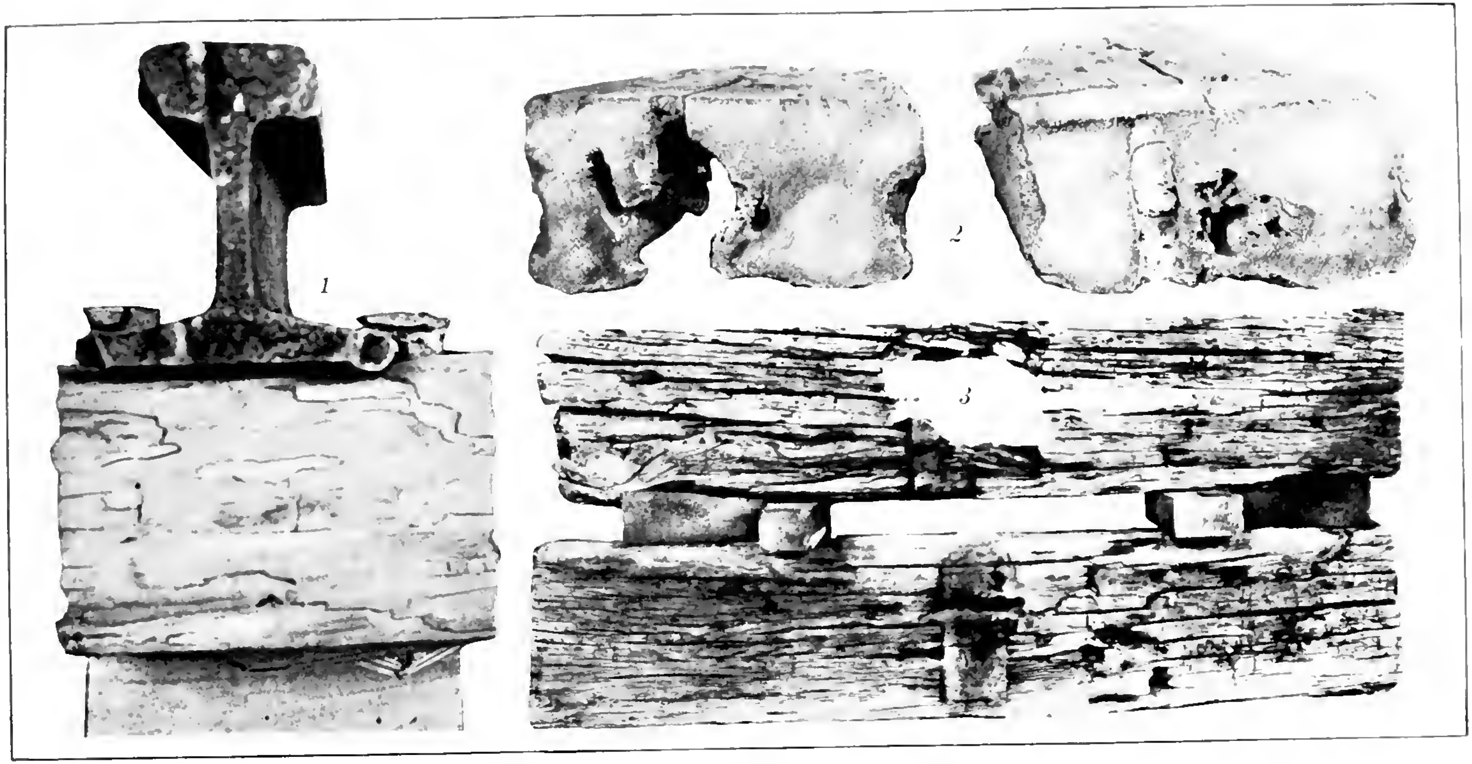



PLATE VIII. RAILWAY SLEEPERS DAMAGED BY TERMITES.

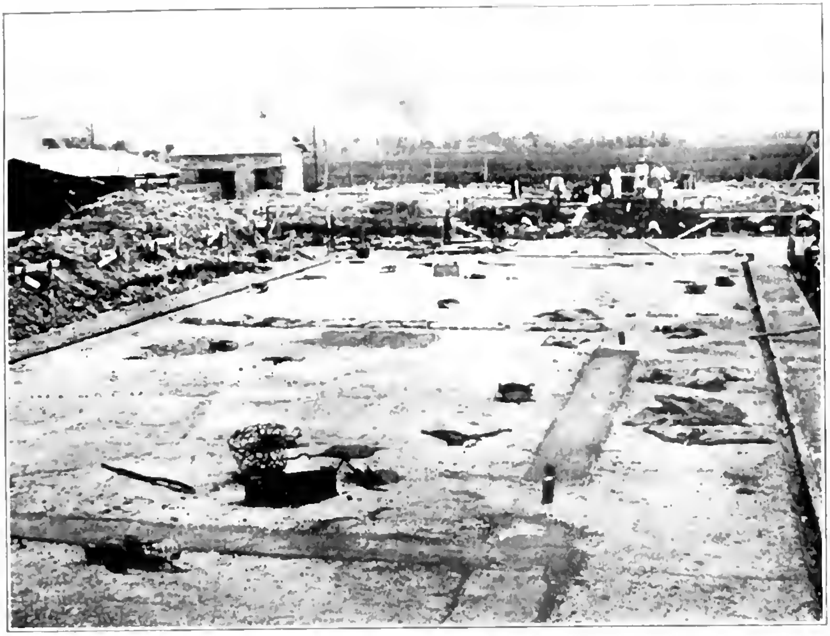


Fig. 1. Construction of a termite-proof concrete layer.

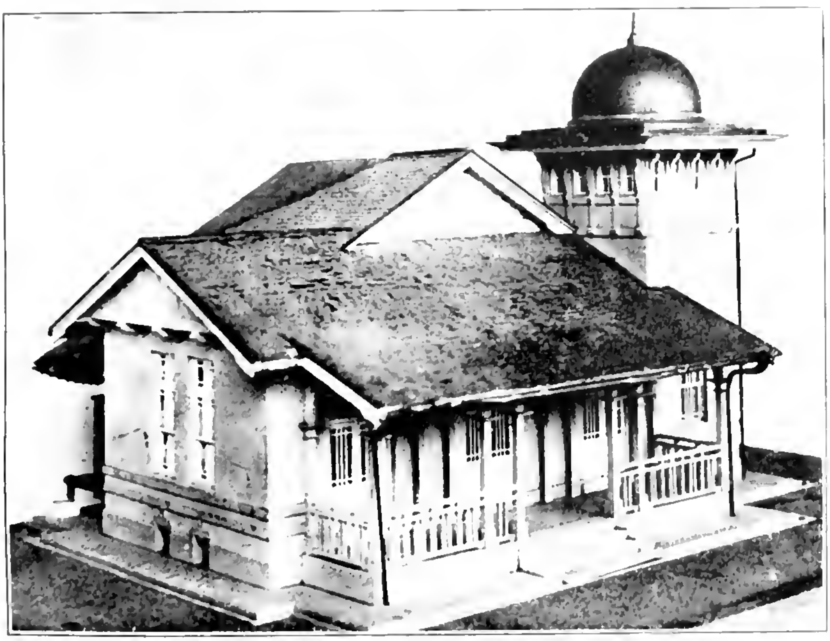


Fig. 2. Model of a termite-proof building.

PLATE IX.

Fig. 1. A termite-proof brick building.

Fig. 2. Damage to woodwork on second floor of the building shown in fig. 1.

PLATE X.

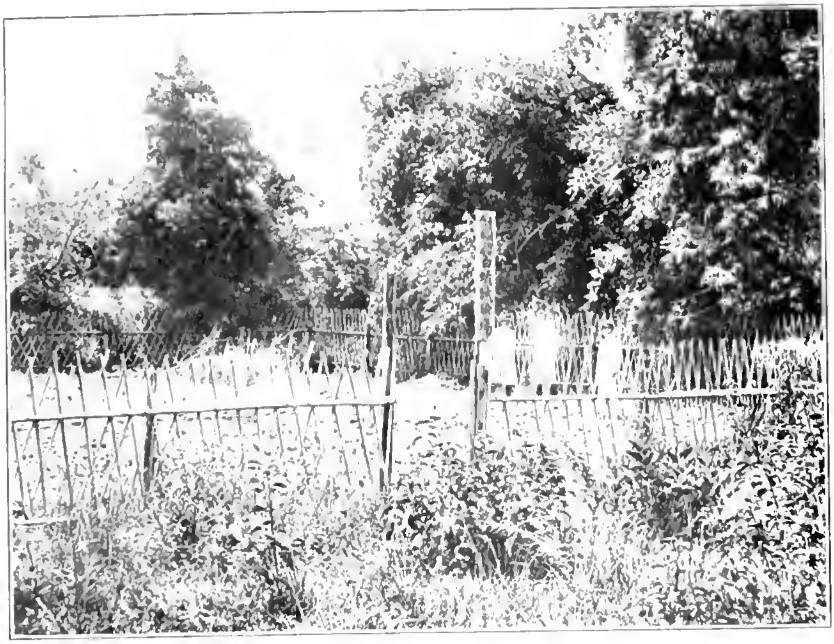
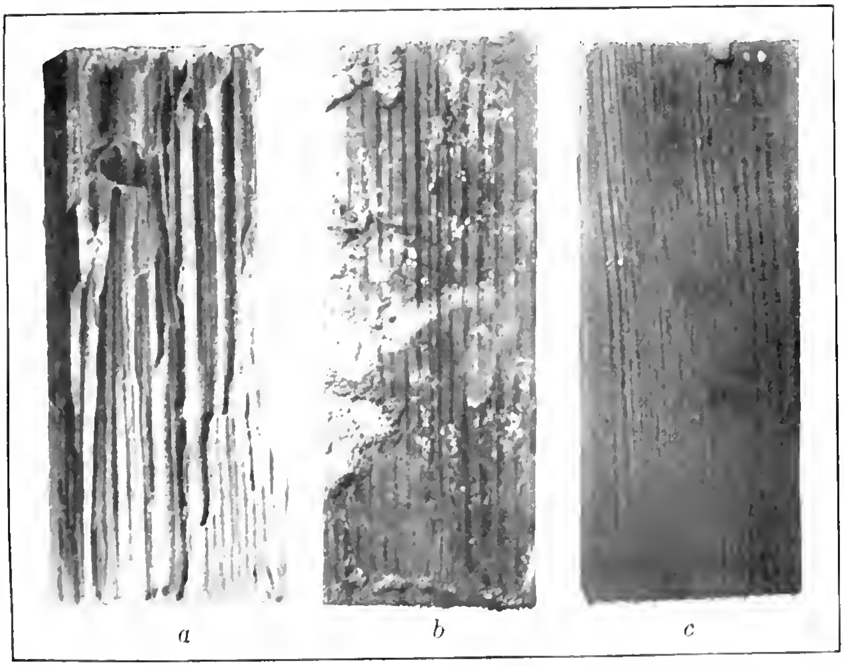


Fig. 1. The experiment station at Tainan, Formosa.



a b c

Fig. 2. Test blocks of pine.

PLATE XI.

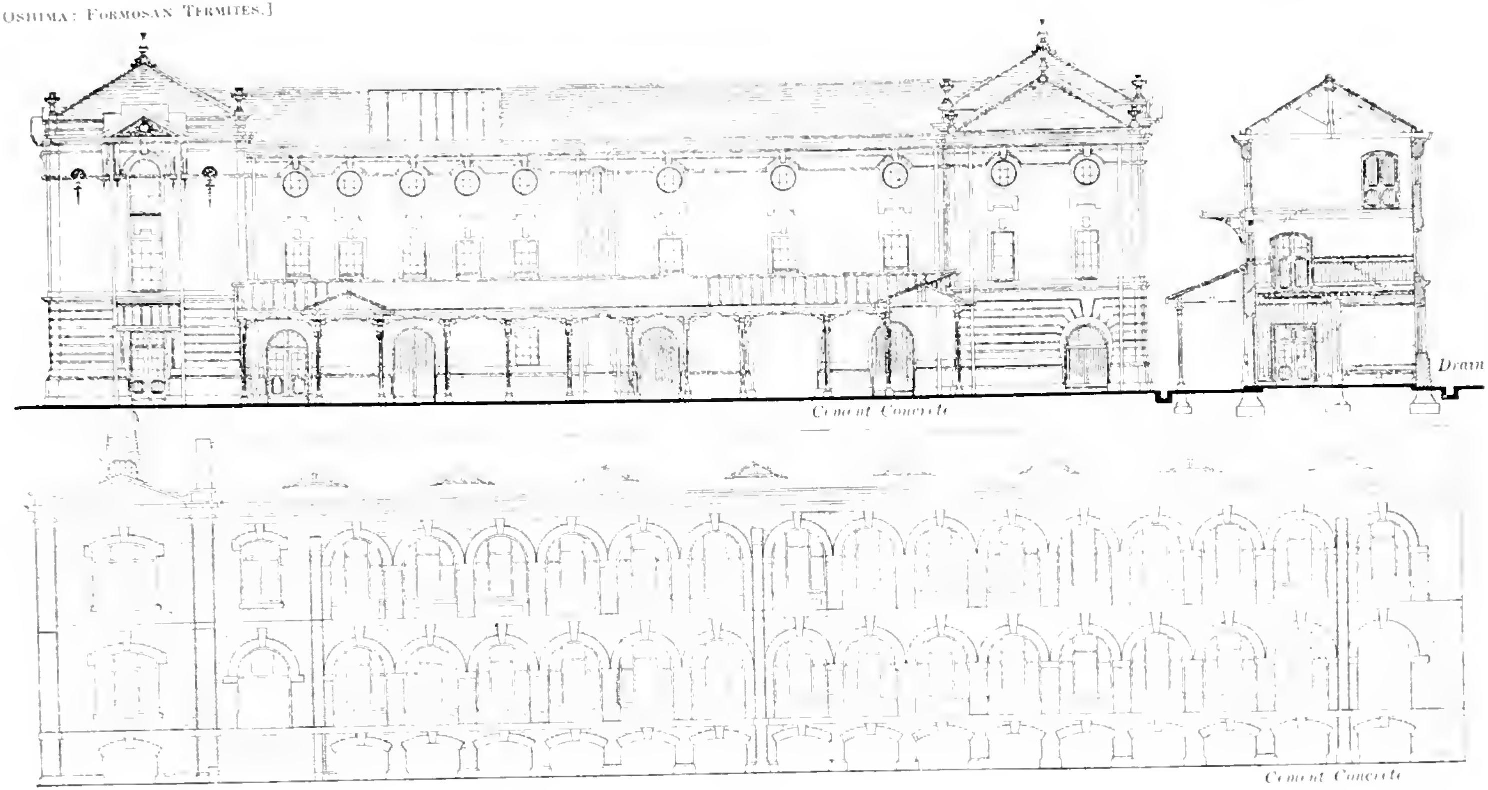



PLATE XII. EXAMPLES OF TERMITE-PROOF BRICK BUILDINGS.

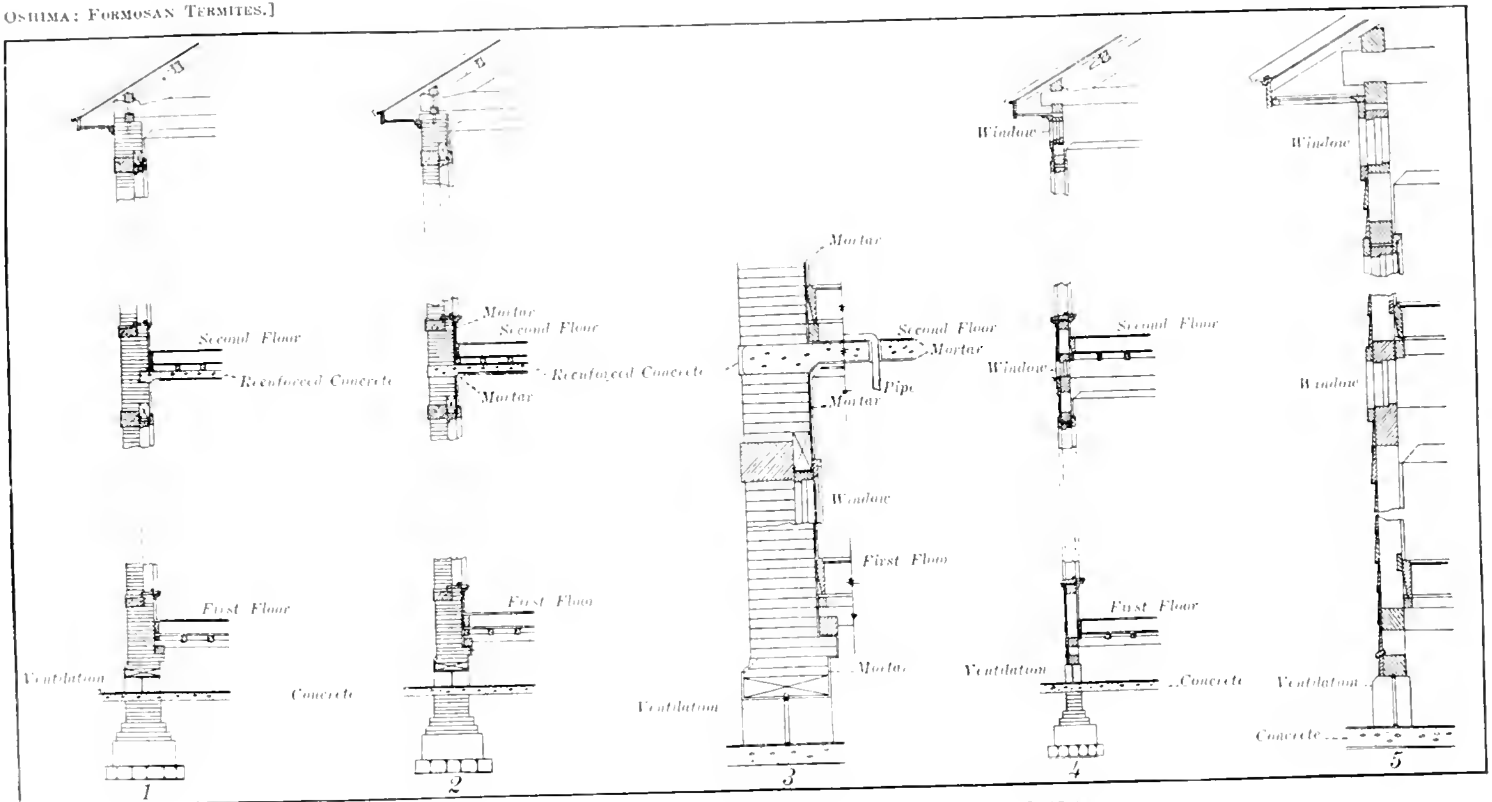



PLATE XIII. EXAMPLES OF TERMITE-PROOF BUILDING CONSTRUCTION.

# A NEW SCALE INSECT ON RHIZOPHORA

By T. D. A. Cockerell

*Of the University of Colorado*

ONE TEXT FIGURE

The mangroves (*Rhizophora*), fringing tropical shores, have been found to support a peculiar coccid fauna, including *Ctenochiton rhizophoræ* Maskell in Australia, *Mesolecanium rhizophoræ* Cockerell in Brazil, and *Chrysomphalus rhizophoræ* Cockerell in Mexico. A new species is now to be described from the Philippine Islands.

Targionia merrilli sp. nov. Text fig. 1.

Female scale 3 to 3.5 millimeters in diameter, flattened, somewhat convex, circular, pale gray; first skin near margin, appearing as a small black nipplelike prominence. Young scales reddish, with the first skin orange.

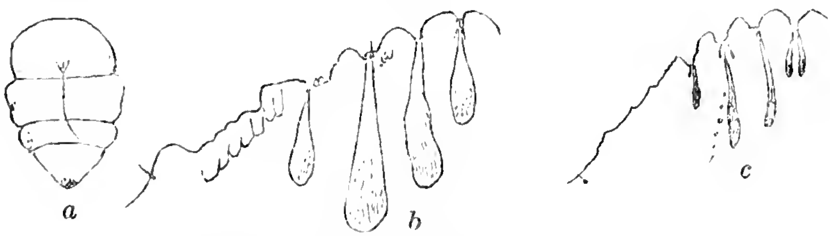



Fig. 1. *Targionia merrilli* sp. nov., *a*, female insect; *b*, caudal end of female; *c*, *Chrysomphalus rhizophoræ* Cockerell, caudal end of female.

Female dark brown, about 2.5 millimeters long; cephalic region broadly rounded, separated by a deep suture from the wider thoracic region; no circumgenital glands; anal orifice narrow and elongate, about 100 $\mu$ from hind end; five pairs of low lobes, the first broad and close together, but not touching; second and third broad and rounded, the third sometimes distinctly notched; fourth very broad, with the margin variable, but usually more or less flattened or tablelike in outline; fifth rounded, widely separated from fourth; spines small and inconspicuous; squames very minute, rudimentary; at the bases of the lobes are long claviform paraphyses or glands, one be-

tween median lobes; one, nearly twice as long, between first and second lobes; a similar one just mesad of third lobe; and a smaller one mesad of fourth lobe.

On upper and under sides of leaves of *Rhizophora mucronata* Lamarck, Manila, Philippine Islands, September, 1918 (*E. D. Merrill*).

This is a very distinct species, somewhat related to *Targionia mooeri* (Green), from India, but easily recognized by the numerous lobes and large claviform thickenings or glands, which recall those of *Chrysomphalus quadriclavatus* (Green), found on *Murraya exotica* in Ceylon. Green calls these structures clubbed paraphyses. It is rather remarkable that the Mexican *Chrysomphalus rhizophoræ*, which has groups of circumgenital glands and is not closely related to *Targionia merrilli*, also has very long paraphyses. I give a sketch of the caudal end of this insect (not before figured) for comparison.

## ILLUSTRATION

**TEXT FIGURE**

FIG. 1. *Targionia merrilli* sp. nov., *a*, female insect; *b*, caudal end of female; *c*, *Chrysomphalus rhizophoræ* Cockerell, caudal end of female.

# BALANTIDIUM HAUGHWOUTI, NEW SPECIES, PARASITIC IN THE INTESTINAL TRACT OF AMPULLARIA SPECIES, A MORPHOLOGICAL STUDY

## WITH REMARKS ON THE RELATION BETWEEN THE MEGANUCLEUS AND THE MICRONUCLEUS [1]

By WALFRIDO DE LEON

*Instructor, Department of Pathology and Bacteriology, College of Medicine and Surgery, University of the Philippines*

ONE PLATE AND FIVE TEXT FIGURES

### INTRODUCTION

This is a study of the structures and the characters of what appears to be a new species of *Balantidium* found parasitic in the intestinal tract of a fresh-water snail, *Ampullaria* sp. The parasites were first seen by Prof. Frank G. Haughwout in the original host found in the pond on the ground of the Bureau of Science, Manila.

The host, *Ampullaria*, is a very common inhabitant of fresh waters in the Philippine Islands. It thrives luxuriantly about the banks and the bottoms of shallow rivers and ponds. It is known in the vernacular as "cohol" and is much used as a food by the Filipinos.

The discovery of this species is of some systematic interest in that it forms an addition to the species of *Balantidium* that have been found infesting invertebrate hosts.

### THE GENUS BALANTIDIUM

The genus *Balantidium* was founded by Claparede and Lachman.(10) It consists of heterotrichous ciliates, free-swimming or histozoic, oval in shape, slightly truncated anteriorly and more rounded posteriorly. A small triangular excavation, anteriorly, forms the peristome at the bottom of which opens the cytostome which leads backward into a fairly well-developed

[1] From the department of parasitology. Submitted in partial fulfillment of the requirements for the degree of Doctor of Tropical Medicine, Graduate School of Tropical Medicine and Public Health, College of Medicine and Surgery, University of the Philippines.

or rudimentary cytopharynx. The peristome area bears an adoral zone of membranelles which are continuous with a line of slender, delicate cilia or membranelles which line the gullet. An anal aperture or cytopyge is usually present at the most posterior point of the body. Contractile vacuoles are present in varying numbers. The meganucleus is oval, bean-shaped, or reniform. The organisms occur as entozoic parasites of vertebrates and invertebrates.

Systematically the genus *Balantidium* falls in the subphylum Infusoria; class Ciliata; order Heterotrichida; suborder Polytrichina; and family Bursaridæ. In this genus are included the following species:

Balantidium entozoön Ehrenberg.

Found as an obligate parasite in the rectum of the common frogs *Rana temporaria* and *R. esculenta*. It was first described by Leeuwenhoek in 1722. It has an oval or pyriform body, narrowed anteriorly. This narrow anterior end is somewhat curved to one side and obliquely truncate. It is provided with a peristome area which extends backward and continues into a well-defined gullet. There are four contractile vacuoles. The meganucleus is sausage-shaped. It measures 105 $\mu$ to 635 $\mu$.

Balantidium elongatum Stein.

Found as a parasite in the intestinal canal of *Triton tæniatus* and *Rana esculenta*. It has a length of 212 $\mu$ to 302 $\mu$ which is two to two and one-half times its breadth. The body is "elongate-fusiform, subcylindrical," tapering anteriorly. The peristome area is slitlike, short, and lies in a medium position without any distinct cytopharynx. There are usually two distinct vacuoles. The meganucleus is oval in shape.

Balantidium coli Malmsten.

This species was discovered in the bowel discharges of two patients suffering from chronic diarrhœa. The organism was described by Malmsten under the designation *Paramecium coli*. Stein later discovered the same species in the intestinal tract of hogs. The body is oval, the anterior end being either broader or more pointed, according to the degree of contraction of the peristome area. It measures 60 $\mu$ to 100 $\mu$ in length and 50 $\mu$ to 70 $\mu$ in width. The peristome is triangular or funnel-shaped. The pharynx is not very distinct. There are two contractile vacuoles. There is a cytopyge that is postero-terminal. The meganucleus is bean-shaped or reniform. The micronucleus is

small and spherical. This is the only species so far proved to be pathogenic to its host.

**Balantidium duodeni** Stein.

This species has been found in the duodenum of the edible frog *Rana esculenta*. It differs from *Balantidium entozoön*, a parasite of the same host, in that the cuticular cilia of *B. duodeni* are longer and finer and are "mostly directed forwards and have a tendency to group themselves into even, longitudinally disposed, pencil-like tufts." It has a length of 85 μ to 132 μ, barely exceeding its breadth. It has a short, oval, flattened body with a short, narrow, slitlike peristome. There is no distinct cytopharynx. The meganucleus is oval. There is only one contractile vacuole, and this lies at one side of the body posteriorly.

**Balantidium medusarum** Mereschowsky.

Parasitic in the alimentary and radial canals of the medusæ of the coelenterate forms *Eucope* and *Bougainvillea*. Brada, as quoted by Saville-Kent(9) has also reported it as occurring in certain marine worms. The body is soft, flexible, and somewhat oval; it measures 42 μ in length, this being about twice the width of the body. The peristome is prolonged backward and is supplied on the left border with an even row of powerful adoral membranelles. The surface of the body is distinctly marked with numerous longitudinal striæ that are interlaced by finer, less conspicuous transverse striations. The body is supplied with long, slender, fine cilia that are well scattered. There are one or two contractile vacuoles. The meganucleus is slightly oval and may be rounded; it is usually central in position.

**Balantidium minutum** Schaudinn.

This is a parasite of the human intestinal tract, its local habitat being the small intestine, particularly the duodenum. It appears only in the stools during active diarrhœa. The body is oval, pointed anteriorly and more rounded at the posterior end. It ranges in length from 20 μ to 32 μ with a width of from 14 μ to 20 μ. The peristome is fissurelike and ends at the center of the body. The right lateral border of this peristome is supplied with a row of cilia of the same size as those appearing on the general surface of the body. The left side expands laterally into a "thin hyaline membrane that extends towards the back and can pass over to the right side." There is a single contractile vacuole situated posterodorsally. The meganucleus is

rounded in shape, centrally placed, and measures 6 μ to 7 μ in diameter. The micronucleus, which lies in its vicinity, is also rounded and measures only 1 μ in diameter. The cysts are oval.

**Balantidium falcifarum** Walker.(12)

Found in the large intestine of the frog *Rana palustris* Leconte. The body is falciform and oval in cross section. The anterior end of the body is narrow and truncated obliquely to the right. The peristome is limited to the anterior end. The cytopharynx is very short. The meganucleus, lying either in the middle of the body or a little posteriorly, has an oval or rounded shape. It measures 3.8 μ to 4.6 μ in diameter. The size of the organism is from 30 μ to 35 μ by 10 μ to 15 μ. According to Walker it sporulates on artificial media. The cysts are round and single-walled and their contents granular.

**Balantidium orchestis** Watson (Kamm).(13)

Parasitic in the alimentary tract of *Orchestia agilis* and *Talorchestia longicornis.* The body of this species is ovoidal or ellipsoidal and measures from 300 μ to 360 μ in length with a width of from 180 μ to 220 μ. The meganucleus is ellipsoidal. The micronucleus, which is small, lies close to the meganucleus. The peristome is small and inconspicuous and leads into a short, slender œsophagus. There is a single contractile vacuole at the posterior end.

**Balantidium coli var. hondurense** Barlow.

This is described by Barlow as differing from *Balantidium coli* in that the cilia are not arranged in rows; there is no contractile vacuole; and the cytopyge, or anus, is contractile. The micronucleus, Barlow says, is difficult to demonstrate. This is an interesting form that requires further study.

**Balantidium italicum** Sangiorgi and Ugdulena.(8)

This is described by Sangiorgi and Ugdulena as very similar to *Balantidium minutum* Schaudinn, the only differences being the eccentric position of its nuclear apparatus and the inconstant relative position of the micronucleus with regard to the meganucleus. This organism has been found in human diarrhœic stools. It has been successfully cultivated in peptone water and agar-agar media. The average size of those grown in peptone water is 31.5 μ by 14 μ and those grown in agar, 33 μ by 25 μ.

Fantham, Stevens, and Theobald(3) mention species of *Balantidium* occurring in polychæte annelids, and various authors have described balantidia from the human intestinal tract to which

they have given new specific names. In the latter case the question arises as to the validity of these species, and further work on them is clearly indicated.

### MATERIAL AND METHODS

In studying the parasite to be described the snail host was dissected, the intestinal tract isolated and where whole mounts were needed the intestinal contents were teased out, smeared directly over the slides, and immediately fixed. Intestines were sectioned at different levels to detect the site of parasitism as well as to throw light on the matter of tissue invasion. Sections of individual balantidia were also prepared for the study of the minute cytoplasmic and nuclear structures. In every case fixation was carried out either in sublimate-acetic fluid [2] or in Bouin's picro-aceto-formol solution. Sections were stained either by Heidenhain's iron-hæmatoxylin or by the iron-hæmatein method of Dobell.(2) Total mounts were stained with Delafield's hæmatoxylin or with the picro-carmine of Hoyer.

The living organisms were studied in the intestinal fluid of the host or in physiological salt solution.

The animals to be measured were killed in Worcester's fluid [3] and measured directly by the ocular micrometer at a magnification of 1,280 diameters. Both large and small individuals were taken at random as they occurred on the slide.

The proportion of infected snails was found to be about 95 per cent, after the animals had been kept in the laboratory aquarium for a few days; but if examined immediately after they were taken from the pond, fully 99 per cent of well-fed snails containing an abundance of food in the gut were found to be parasitized. As the snails are kept longer in the laboratory and the intestinal contents diminish as a result of the lessening food supply the heaviness of the infection is correspondingly lowered. Under such conditions of partial starvation the parasites look lean, flat, transparent, and granular, instead of robust and alveolar. If they are kept a few weeks longer in the laboratory, examination of all the snails will prove negative.

Under these conditions the parasites apparently leave their host, either being discharged with the intestinal contents or swimming out by themselves to assume the exogenous phase in

[2] Saturated solution of mercuric chloride in sea water, 95 parts; glacial acetic acid, 5 parts.

[3] Saturated solution of mercuric chloride in 10 per cent formol, 9 parts; glacial acetic acid, 1 part.

their life cycle. As the snails are kept longer in the aquarium the balantidia apparently increase in numbers in the water of the aquarium. Whether or not they divide under these circumstances cannot be said. Outside of the snail, however, they seem to have but a short period of existence, as free-living forms, since they disappear in four or five days. Whether they encyst at this period or succumb to the toxic substances produced by the overgrowth of bacteria and spirilla is yet to be determined. So far, the cysts have not been determined with certainty.

## SITE OF PARASITISM

Smear preparations of entire organisms and sections 5 μ thick cut from different portions of the gut show that the parts most infested are the mid- and the hind-guts, especially those parts usually rich in intestinal contents from which the animal mainly derives its food.

In these sections the organisms were always found confined to the lumen of the gut, lying in the intestinal content. I never have observed an instance where tissue had been invaded or, indeed, any evidence that might be interpreted as an attempt to penetrate the intestinal wall.

## MORPHOLOGY

In fresh preparations the organism has the appearance of a miniature balloon, slightly flattened dorsoventrally, tapering evenly and gradually to a blunt anterior end and expanding into a posterior rounded extremity where, often, a very minute conical papilla can be seen. At this spot is located a minute anal opening, the cytopyge, attached to which, in an actively feeding animal, can be observed a stalk that looks like a mucoid thread. In one instance I observed an individual attached to a fragment of intestinal tissue by means of this "stalk." The structure, in a way, recalls the attaching organ of the free-living hypotrichous ciliate *Ancystropodium maupasi* as described by Fauré-Fremiet.(4) The anal papilla somewhat resembles apparently similar structures figured by Stein in connection with his descriptions of *Balantidium coli* and *B. duodeni*.

Viewed from the sides the dorsoventral flattening of the body is very apparent. Ventrally, at about the junction of the anterior and middle thirds of the body and just at the site of the ventral lip, the median portion is depressed, forming an inpocketing that constitutes the triangular excavation at the bottom of which lies the opening of the cytostome. Under normal

conditions, the animal maintains a constant body form and externally is bilaterally symmetrical. When disturbed, however, as when it is placed in a foreign medium, the animal can assume a slipperlike form with marked flattening. This may at times give an appearance superficially resembling that of *Paramoecium caudatum*. This illustrates the marked plasticity of the organism. When placed under restraint, as by pressing the cover glass down against the slide, or when the animals are compelled to swim through tangled strands of cotton, this plasticity enables them to assume shapes so varied that when seen for the first time under such conditions they might almost be mistaken for amœbæ. This is a phenomenon of frequent occurrence among the Ciliata.

Placed in their natural medium, that is to say, the intestinal juice of the host snail, these organisms can be seen to progress evenly and gracefully with a slight rotary motion. When slightly disturbed or placed in a foreign medium they move rapidly by a series of jerks and dashes and sudden turns, coupled with vigorous rotation about the long axis. When put under pressure or placed under some obstruction the animals take on the "amœboid" movement before mentioned, the elasticity and the flexibility of the cell wall being well shown under these conditions. This movement, however, is not amœboid movement in the true sense.

Furthermore, the anterior end of the animal seems capable of protrusion to a considerable extent, and it is likewise capable of flexion in every direction. In this respect the anterior end of the animal really behaves very much as does the pseudopodium of a rhizopod, apparently serving to guide the animal in forward progression among obstacles. The rest of the body follows by successive regional contractions and adaptations of the cell wall accompanied by rapid cyclosis of the endoplasm in the direction of the anterior end. The coarsely granular protoplasm, the nuclei, and the vacuoles follow the anteriorly situated finely granular endoplasm.

This species is one of the smaller of those included in the genus *Balantidium*. Its average length, computed from a series of fifty individuals selected at random, was 50 $\mu$; the average width was 40 $\mu$. The animal is widest at the posterior third of the body, the anterior third being the narrowest portion.

## CYTOLOGY

The organism is clothed with a fairly thick cuticle—homogenous, transparent, and refractive. Under ordinary conditions this cuticle appears to be firm enough to keep the shape of the animal constant, and yet under certain circumstances it is seen to be flexible enough to allow considerable movement and change of shape. The cuticle is traversed by longitudinal lines or striations, which on the dorsal surface run from pole to pole; on the ventral surface, anteriorly, they curve dorsad and converge, following the depression that marks the position of the adoral zone. From these lines spring the comparatively long, slender, and delicate cilia, the coördinated fibrillary movements of which propel the animal forward. I have been unable to demonstrate basal granules at the origin of the cilia. It is not certain that these longitudinal lines actually are ridges because in cross sections of the organisms the cuticle does not show any raised or differentiated areas. It is probable that the lines represent the insertion of myonemes, the contractions of which bring about the movements of the body. The seeming absence of basal granules might be explained on the basis of the supposition that kinetic elements, common to both the myonemes and the cilia, are contained within the myonemes.

These lines are plainly visible in the living organism, but are hard to distinguish in the fixed and stained specimens. While the contractile mechanism of this species is somewhat similar to that seen in the closely related genera *Stentor* and *Spirostemum*, the body does not show the high degree of contractility exhibited by those two nonparasitic forms.

The medulla consists of two distinct cytoplasmic zones; namely a finely granular ectoplasm, and a coarsely granular endoplasm.

The ectoplasm consists of a narrow strip of clear, almost homogenous, refractive, and finely granular cytoplasm around the periphery of the cell which, just above the terminus of the cytopharynx and at the level of the oral depression, apparently expands and becomes continuous with an area of similar structure occupying the anterior third of the organism. This is probably an optical effect due to the thinness of the body at this point and where the endoplasm would appear to be relatively scant in quantity.

This anterior third of the animal is a blunted cone which is excavated ventrally. Its base is represented by a line of demarcation sharply seen (see fig. 2, *b* and *c*), especially in the

fresh specimen, at its junction with the middle third convex superiorly, dividing abruptly, the finer granular and the coarsely granular cytoplasm lying posterior to it. This constitutes the upper limit of the latter. At the extremities of this line may be observed, in favorable individuals, a slight constriction or indentation of the cell wall forming some sort of a neck to the individual, a fact which shows that the posterior portion is more elastic and expansible laterally than the anterior which, as has been previously noted, is capable of comparatively wide extension along the longitudinal axis. Moreover, this line corresponds, on the ventral surface, to the edge or ventral lip of the oral excavation.

Dorsally, at the most anterior part of this conical structure, a row of membranelles is seen constantly in motion. This dorsal portion constitutes the dorsal lip of the adoral excavation. It is continued laterally on both sides as a thin expansion forming the lateral wall through which, under deeper focus, can be seen the structure of the oral apparatus. Ventrally, the median anterior surface does not reach the most anterior part of the animal. Instead it makes an acute dorsoposterior fold to form the adoral excavation already mentioned.

The excavation itself is funnel-shaped. At the bottom of it lies the cytostome which leads into a small canal, the cytopharynx, which, in turn, runs a short course dorsoposteriorly to end blindly in the endoplasm in the vicinity of the meganucleus. The opening between the dorsal and ventral lips measures about 11.5 $\mu$. The adoral zone is well supplied with membranelles. The cytopharynx is ciliated. The united action of these membranelles and cilia, the movements of which are coördinated, serves to conduct the current of food to the endoplasm. The dorsal lip of the adoral excavation is probably supplied with myonemes, since the oral area can be much expanded during active feeding.

The posterior two-thirds part of the animal is darker and coarser in appearance because it contains coarse, dark granules having a greenish tinge. In recently well-fed animals these granules have a deeper color, more or less bluish green, and the granular appearance is overshadowed by a distinctly alveolar structure. This alveolar appearance is apparently due to the rapid production of a great abundance of food vacuoles, and the greenish coloration would seem to be derived from the chromophyll substance present in the bodies of the vegetable forms of

life ingested by the snail which constitute a portion of the diet of the parasite.

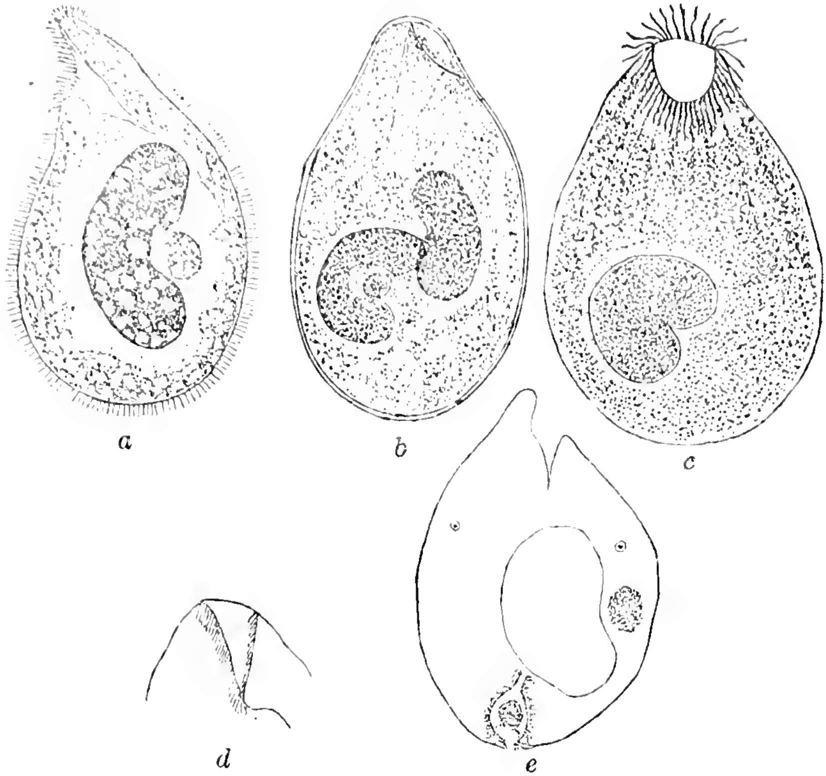


FIG. 1. Oral and excretory apparatus of *Balantidium haughwouti*.

In this portion of the parasite the meganucleus and the micronucleus can be seen, floating and eddying about in most intimate association in the rapid and constant cyclosis of the endoplasm; abundant food vacuoles; fragments of vegetable cells or smaller protozoa, partially digested; and, in some instances, contractile vacuoles. In stained preparations of lean individuals, where the alveolar structure does not obstruct the view, this area is traversed by an intricate system of numerous minute, canal-like structures (see fig. 1, *b*), seen as clear homogenous-appearing lines running through the granular substance. Whether they represent true canals, lines of conduction of excretory products, or are merely artifacts due to unequal shrinkage of protoplasmic elements in the fixing fluid, remains to be determined.

If the former, we should have a condition such as that obtaining in the gregarine-like infusorian *Pycnothrix monocystoides*.

In that organism the endoplasm is traversed by a branching and ramifying system of excretory canals which unite and discharge into a single ciliated efferent duct that opens externally into a pore located at the surface of the body near the posterior end. It should be noted that in *Pycnothrix*, and also in *Opalina*, the excretory systems are endoplasmic, a condition differing from the ordinary cases in the protozoa where the vacuoles are located in the ectoplasm. Both of these forms, however, are nourished by the osmotic method, whereas *Balantidium haughwouti* is holozoic. Furthermore, this balantidium possesses definite contractile vacuoles, which can be seen to pulsate regularly.

In a rapidly moving animal, possibly caused by the pressure resistance of the surrounding medium, the tiny conical papilla already mentioned can be seen with considerable distinctness. The cytopyge (see fig. 1, *e*), as has been said, opens at the tip of this papilla and from it can be seen to issue solid substances and a mucuslike material. Shrinkage in fixation seems to obliterate this papilla, and in the stained preparations the cytopyge only is seen as a minute opening at the posterior extremity. This anal pore is apparently the terminal point of the canal system mentioned in the preceding paragraph, and it is from this that the mucuslike thread is seen to originate.

This, of course, raises the question as to whether there are two distinct systems present; namely, a definite cell anus connected with a canal system providing for the collection and discharge of unused substances taken in by the organism, and a contractile vacuole system of the conventional type which cares solely for the products of catabolism. This is a point I have been unable to determine even by feeding carmine granules to the animals. It is, however, a condition not unknown in the Infusoria.

The contractile vacuoles are seen as one or two well-defined clear spaces just posterior to the meganucleus. Their formation is slow and gradual. They are buoyed to and fro by the cytoplasmic movements and, as they enlarge in volume, appear to migrate to the extreme periphery, approaching the cuticle suddenly to empty their contents through the cuticle to the exterior.

The meganucleus is a conspicuous body lying in the endoplasm. It can be distinguished from the granules and food vacuoles in the living organism by its transparent, homogenous, and colorless appearance. It is flexible to a degree, a characteristic not uncommon in the Infusoria where nuclei such as are seen in the suctorians *Acineta* and *Ephelota* show amœboid contortions.

In stained preparations the meganucleus is the most conspicuous intracellular object. It takes the stain deeply and it is only by good differentiation that its true structure is seen. The shape of this nucleus is quite characteristic. In the vegetative state of the cell its normal form might be said to be sausage-shaped to reniform, but it shows an orderly and progressive series of form changes that develop until it has finally completely curved upon itself to form a circle with the two ends of the nucleus in apposition. The micronucleus is usually lodged in the concavity of the meganucleus and tends to become enclosed by it. The possible significance of these form changes will be discussed later.

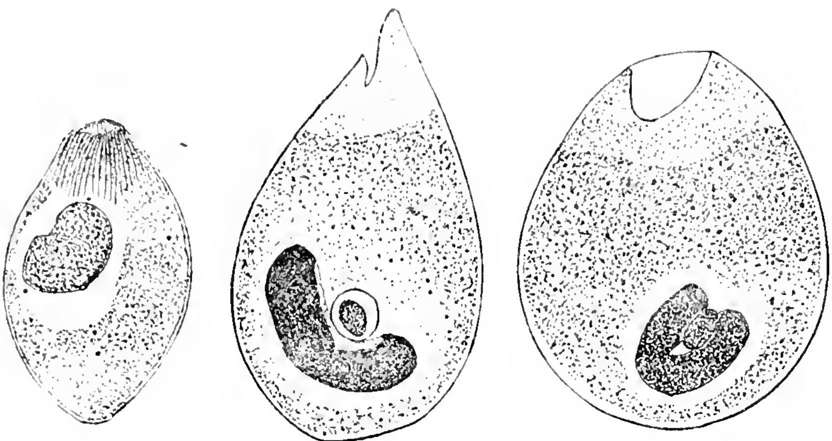



FIG. 2. Cytoplasmic structure and meganuclear and micronuclear relations in *Balantidium haughwouti*.

In stained preparations the meganucleus measures on the average 19.83 $\mu$ in length by 7.5 $\mu$ in width. In general shape it closely resembles the meganucleus of *Balantidium coli*, and that of *B. entozoön* as figured and described by Stein, who appears to have noticed the same variation in form.

In deeply stained specimens the meganucleus appears to be formed of a solid mass of chromatin. Careful differentiation shows the chromatin to be distributed in the form of fine granules more or less closely packed together. The appearance varies, however, so that the finer structure frequently appears as a reticulum of varying texture. Many nuclei show areas that appear more or less alveolar—that is to say, give the appearance of a network of chromatinic material surrounding clear spaces

or areas of achromatinic substance. The whole is inclosed in a delicate nuclear membrane.

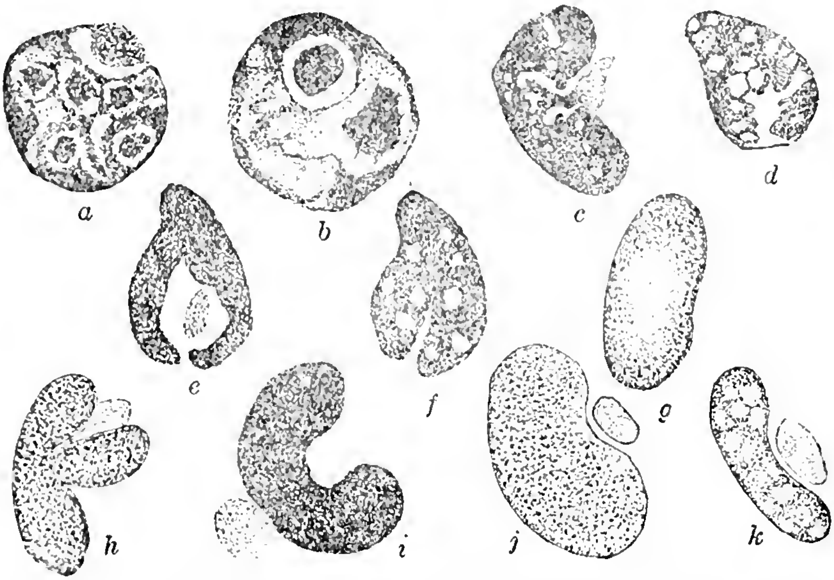



FIG. 3. *a*, *b*, and *c*, Meganuclei of the reticulate type (*a*, superficial; *b*, middle; and *c*, deep focus); *d*, *e*, and *f*, optical sections of a reticulate meganucleus; *g*, meganucleus viewed from its convexity; note the extreme thinness of the "crown" of the nucleus under which lies the micronucleous; *h*, bipartite meganucleus; micronucleus partly shown; *i* and *j*, meganuclei of granular type; *k*, meganucleus of alveolar type.

The finer structure of the meganucleus, as seen in the normal vigorous infusorian, is that of an evenly distributed network of chromatin granules compactly arranged. This structure is, of course, only demonstrable in well-stained and properly extracted preparations. Irregular clumping of the chromatin into a series of groups which gives the appearance of a vacuolated nucleus has been interpreted by various investigators as supervening on unfavorable conditions and as presaging disaster to the organism. I see no support for such a supposition in this instance. All the individuals showing a nucleus of this type were vigorous-appearing cells, exhibiting no signs of the vacuolation and distortion so characteristic of the infusorian cell in distress.

In addition to the regular series of incurving forms, other striking and interesting changes are seen in the structure of the meganucleus. Individuals have been seen in which there were two well-formed meganuclei in the cell. I am inclined to interpret this as, possibly, a result of abnormal distribution of the meganuclear anlagen in the ex-conjugant stage following syngamy, which process, however, I have not observed.

Many cells have been encountered in which the meganuclei have undergone marked changes in shape and appearance. In these cases the nuclei have become spherical or globular and the chromatin is condensed into deeply staining bands or clumps, in the meshes of which is seen clear, achromatinic material. The micronucleus in these cases seems to be sunk deeply into the substance of the meganucleus.

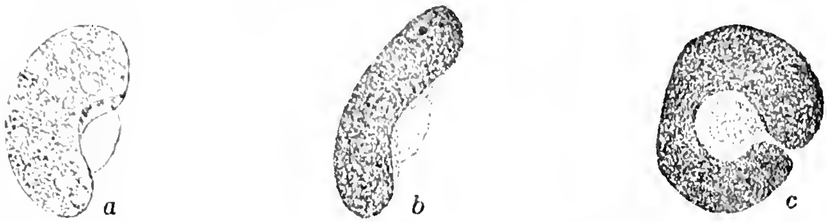



FIG. 4. *a* and *b*, Early stages in inclosure of micronucleus in meganucleus; *c*, later stage.

Other individuals have been seen lacking even a trace of either nucleus, and there are those in which either one or the other nucleus is absent. In such animals there can be seen in the endoplasm fragments of stained substance, possibly of the nature of chromatin, and in one case there was observed (see fig. 5, *c*) a structure which, to all appearances, was the membrane of the meganucleus lacking its chromatin contents. It is impossible at present to arrive at any definite conclusion regarding the real nature of these chromatinic bodies. Walker(12) has described a process of sporulation in *Balantidium falcifarum*, and Stein(10) hints at something of the same nature as occurring in *B. entozoön.* The possibility of endomixis as described by Woodruff and Erdmann must also be borne in mind, but the evidence here is too slight to admit of a discussion of any of these points. The possibility of these bodies being ingested organic matter must likewise be considered. The disappearance of the micronucleus may yet be explained by its incorporation into the meganucleus. Apparent total absence of both nuclei in an uninjured individual is mysterious unless explained on the basis of the fragmentation of both nuclei, or as a result of abnormal division following conjugation.

The micronucleus is a small rounded or elongate body. It is strikingly different in size and structure from that of either *Balantidium coli* or *B. falcifarum,* but most closely resembles Stein's figure of the nuclei of *B. entozoön.* When round it has an average diameter of 3.3 $\mu$, but when elongated it measures 6.88 $\mu$ by 4.22 $\mu$. It seems likely that the normal shape is spher-

ical and that the elongation and the consequent increase in size are early evidence of beginning nuclear division.

This nucleus is invested with a delicate nuclear membrane very difficult to demonstrate. There appears to be a cortical layer of homogenous transparent material that stains very lightly with the nuclear stains. In the gross, it appears to be practically a structureless body. Carefully differentiated spec-

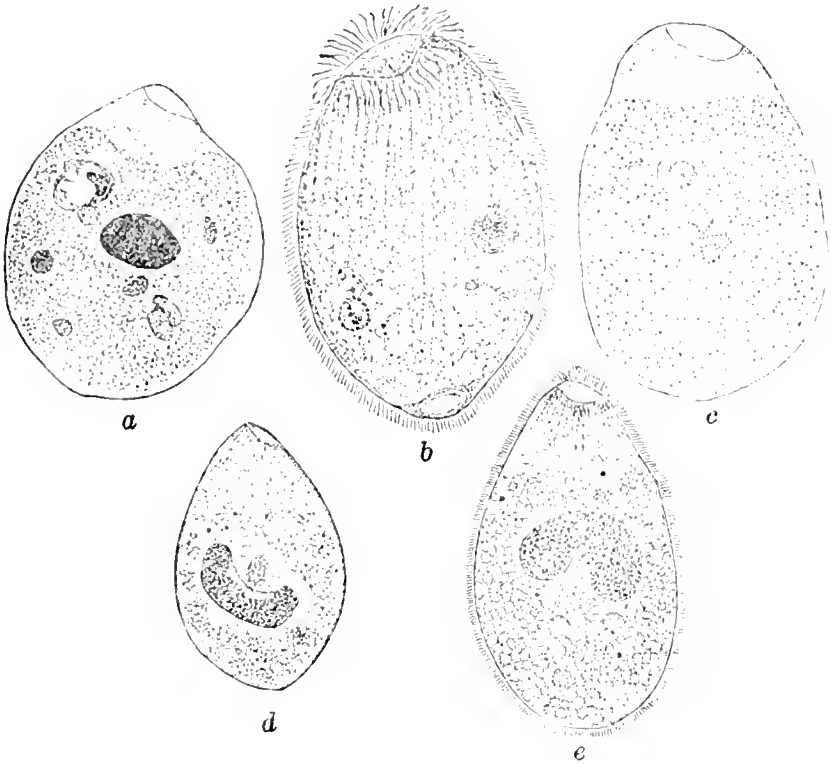



FIG. 5. *a*, A small meganucleus is present; the micronucleus seems to have fragmented; *b*, the meganucleus and its membrane have disappeared; the cytoplasm contains chromatinic bodies of unknown nature; *c*, the meganucleus has disappeared leaving a body that appears to be its membrane; the micronucleus appears in a distinct capsule; *d* and *e*, early and late stages showing the incurvation of the meganucleus about the micronucleus.

imens show, however, that within this achromatinic cortical layer there lies a minute chromatinic granule, or a collection of granules irregularly distributed on a reticulum. This heavy achromatinic cortex is not present in the micronucleus of either *Balantidium coli* or *B. falcifarum*.

It is a little difficult to determine how much of this "cortex" is plastinoid substance or how much of it represents nuclear

sap. The single granule would appear to be in the nature of an endosome floating free in a sac containing nuclear sap and, possibly, plastin. In well-differentiated specimens there appears to be an inlying achromatinic network upon which, in many cases, are distributed chromatinic granules. These granules do not appear in all nuclei and their presence may betoken impending nuclear division.

The normal position of the micronucleus is at the concavity of the meganucleus where it fits very nicely and where the meganucleus eventually encloses it within its folds. At times it can be seen well sunk in the notch, and at other times it is lying only on the edge. It may wander out of the meganuclear notch (see fig. 3, *i*) and be found anywhere near the meganucleus or completely separated from it and floating alone in the endoplasm.

Although there is good ground for believing that this animal forms cysts, I have been unable to identify any of them with certainty. Apparently they occur rarely or not at all in the intestinal contents and it seems likely that, after a brief free-swimming stage in the pond water, the ciliates round out and form cysts which settle on aquatic plants to be later taken in by other snails. In other words, apparently the conditions in the intestines of the host as regards food supply are sufficiently favorable to preclude the formation of cysts there in the general run of infections.

Outside of the snail the animals die quickly under experimental conditions. Under natural conditions it is possible that encystation takes place exogenously as has been suggested.

The question of the exogenous life of *Balantidium* is of some interest from the viewpoint of preventive medicine. As regards *Balantidium coli* several observers have reported it as occurring free. Kleine(7) states that he never failed to find "Paramecium coli" or *Trichomonas* in the sewage as it passed out of St. Bartholomew's Hospital, London. He adds that if he wanted to obtain numerous specimens of these organisms all that was necessary was to bottle specimens of the highly diluted sewage and keep them for a period of about three weeks, after which abundant organisms were available.

Such an observation as this requires careful confirmation. In the first place, it practically presupposes an instance of *Balantidium* infections out of all proportion to those that have been reported. It seems highly probable here that Kleine mistook other members of the family Bursaridæ for *Balantidium*. Conn(1) with some reservation has reported *Balantidium coli* as

occurring free in fresh waters in Connecticut, in the United States, but he says nothing regarding the possible source of the parasites. Haughwout (5) has briefly discussed the matter of a free-living stage in the life cycle of *Trichomonas* and raised a question as to the identity of the organisms described by several authors as occurring free.

## METHOD OF FEEDING

These animals are very voracious, continuing to feed, under the cover glass, almost up to the time of death. When feeding they move slowly and evenly forward, producing, by means of the adoral membranelles, a powerful current of water near the anterior end. This current simulates a whirlpool, the vertex of which points toward the oral depression. It is produced by the coördinated succession of rapid lashing movements of the membranelles and cilia from without oralward. This movement produces to the eye the effect of a rotating peristome or the trochal disk of a rotifer. The current of water impinges on the oral vestibule at an effective angle at one side. There is a sideflow which leaves the depression on the opposite side much as is seen in the case of *Vorticella*. There apparently is little, if any, choice of food at the intaking—every object below a certain size is swept into the pharynx; the rest goes out in the sideflow. Such selection as there is must be rapid, judging from the rapidity of the inward and outward flow of water from the oral cavity. It would seem that selection is governed more by the size of particles taken into the oral opening than by the quality.

## THE RELATION BETWEEN THE MEGANUCLEUS AND THE MICRONUCLEUS

This relation presents one of the most interesting features for future work with this species. It is unfortunate that out of many hundreds of individuals studied not one has been seen in division, and no conjugating pairs have been found.

The enclosure of the micronucleus within the meganucleus is too regular in its occurrence to be accidental, or without significance of some kind. Two possibilities suggest themselves: Either it represents a type of nuclear division of a rather new and remarkable kind, or it represents a process of nuclear reorganization perhaps along the line of endomixis. Unfortunately the picture so far presented is too incomplete to admit of definite conclusions regarding either supposition. There is also the added handicap of incomplete knowledge of division phases of the micronucleus.

As a rule, in dividing cells of the Ciliata, the micronuclei divide first by mitosis, division of the meganucleus which comes later being of a direct type often, apparently, in the nature of a more or less mechanical partition of the chromatin.

In the case of *Boveria subcylindrica*, a more or less aberrant genus but with close affinities to the Heterotrichida, as described by Stevens(11), the relation between the meganucleus and the micronucleus at division of the former is much more intimate. At division the micronucleus comes to lie in contact with the meganuclear membrane. The spindle appears usually at one side, but near the posterior end of the meganucleus. Later it stretches along the nuclear membrane with its poles approaching the ends of the meganucleus. The two micronuclei when separated are located at or very near the poles of the dividing meganucleus. It would seem clearly indicated from this that the micronucleus wields a distinct influence over division of the meganucleus, a much more direct influence than is shown in Ciliates generally.

Ikeda and Ozaki(6) have recently described another interesting relation between the mega- and micronuclei of *Boveria labialis,* a new species occurring in the respiratory trees of two Japanese holothurians. Unfortunately, I have been unable to obtain the original paper and have only seen it in abstract. The phenomenon was observed in conjugation. Following zygosis, the synkaryon divides twice. One of these daughter nuclei becomes the micronucleus of the reorganized individual. The other three products of this division undergo degenerative changes and become incorporated into the persisting meganucleus and may be traced in the first and second fissions of the exconjugant boverias.

This merely gives a possible clue to what is going on in this species of Balantidium. It seems possible, and indeed is suggested by some of the figures, that the micronucleus in its incorporation into the meganucleus may come to function as a division center within the substance of the meganucleus, separating out and resuming its identity at the conclusion of the process. In a way this would merely constitute a variation in the process described by Miss Stevens. As to my observation that this constitutes a post-conjugation phenomenon, that must be laid aside, for the present, for the reason that no earlier stages of conjugation have been seen.

Several other interesting cytological points in this species need clearing up, but they must be left for future work.

Another subject for future investigation lies in the determination of the ability of *Balantidium haughwouti* to live in a host other than *Ampullaria*. This is important by reason of the fact that the host is frequently eaten by persons living in the Philippine Islands. As has been stated, it shows no tendency to penetrate the tissues of the host within which it has been studied, but that is no criterion of what it might do in another host. At the same time it would seem that the danger of infection in man by this parasite is rather remote, if for no other reason than that the character of the food it receives in the gut of the *Ampullaria* is such as would involve a rather revolutionary readjustment of the parasite's metabolism on adaptation to a life in the tissues of man.

In conclusion, I desire to designate this species *Balantidium haughwouti* in compliment to the man who first observed it.

## CONCLUSIONS

The characters possessed by this organism indicate its inclusion in the genus *Balantidium*.

Further work is needed to determine definitely the functions of the cytopyge and of the excretory systems.

It is also in order to determine if there is any neuromotor apparatus.

A close relation is shown between the meganucleus and the micronucleus. For the present it is assumed that this has to do with division.

Stained preparations of *Balantidium haughwouti* together with shells of the snail *Ampullaria* from which they were taken have been deposited in the protozoölogical collection at the Bureau of Science, Manila, and at the Smithsonian Institution in Washington D. C.

## ACKNOWLEDGMENTS

To Prof. Frank G. Haughwout, chief of the department of parasitology, at whose instance this study was undertaken, I wish particularly to express my appreciation of the stimulating and material help and encouragement given me throughout the course of the work. I wish to thank Prof. Sol F. Light, who identified the snail host; Dr. Lamberto Leiva for material help; and Prof. Ricardo Fernandez for assistance in translating from the French literature. For permission to undertake this work in another department while a member of the staff of the de-

partment of obstetrics appreciation is due to Dr. Fernando Calderon, chief of the department, and for opportunity to complete it since my transfer to the department of pathology and bacteriology, to Dr. H. W. Wade.

REFERENCES


1. CONN, H. W. A Preliminary Report on the Protozoa of the Fresh Waters of Connecticut. Hartford Press, Hartford, Conn. (1905) 56.
2. DOBELL, C. Cytological studies on three species of ameba—A. lacertae Hartman, A. glebae n. sp., A. fluvialis n. sp. *Arch. f. Protistenk.* 34 (1914) 112.
3. FANTHAM, H. B., STEPHENS, J. W., and THEOBALD, F. V. The Animal Parasites of Man. London, John Bale, Sons and Danielsson Ltd. (1916) 201.
4. FAURE-FREMIET, E. L'Ancystropodium maupasi (n. gen., n. sp.). *Arch. f. Protistenk.* 13 (1909) 121.
5. HAUGHWOUT, F. G. The tissue-invasive powers of the flagellated and ciliated Protozoa with special reference to Trichomonas intestinalis. A critical review. *Philip. Journ. Sci.* § B 13 (1918) 217.
6. IKEDA, I., and OZAKI, Y. Journ. Coll. Sc., Imp. Univ., Tokyo, 40 (1918) art. 6. Reviewed in Nature 102 (1918) 95.
7. KLEINE, E. Paramæcium coli and Trichomonas in sewage. *Brit. Med. Journ.* 2 (1896) 1852.
8. SANGIORGI, G., and UGDULENA, G. Ciliati nell' intestino umano. *Pathologica* 9 (1917) 1.
9. SAVILLE-KENT, W. A Manual of the Infusoria. London, David Bogue (1881–1882) 579.
10. Cited by STEIN, F. Der Organismus der Infusionsthiere. Wilhelm Engelmann. Leipzig 2 (1867) 309.
11. STEVENS, NETTIE M. Further studies on the ciliate infusoria Lichnophora and Boveria. *Arch. f. Protistenk.* 3 (1904) 1.
12. WALKER, E. L. Sporulation in the parasitic ciliata. *Arch. f. Protistenk.* 17 (1909) 296.
13. WATSON, M. E. A new infusorian parasite in sand fleas. *Journ. Parasitol.* 2 (1916) 145.

# ILLUSTRATIONS

## Plate I

*Balantidium haughwouti* sp. nov.

### TEXT FIGURES

Fig. 1. Oral and excretory apparatus of *Balantidium haugnwouti.*

2. Cytoplasmic structure and meganuclear and micronuclear relations in *Balantidium haughwouti.*

3. *a*, *b*, and *c*, Meganuclei of the reticulate type (*a*, superficial; *b*, middle; and *c*, deep focus); *d*, *e*, and *f*, optical sections of a reticulate meganucleus; *g*, meganucleus viewed from its convexity; note the extreme thinness of the "crown" of the nucleus under which lies the micronucleus; *h*, bipartite meganucleus; micronucleus partly shown; *i* and *j*, meganuclei of granular type; *k*, meganucleus of alveolar type.

4. *a* and *b*, Early stages in inclosure of micronucleus in meganucleus; *c*, later stage.

5. *a*, A small meganucleus is present; the micronucleus seems to have fragmented; *b*, the meganucleus and its membrane have disappeared; the cytoplasm contains chromatinic bodies of unknown nature; *c*, the meganucleus has disappeared leaving a body that appears to be its membrane; the micronucleus appears in a distinct capsule; *d* and *e*, early and late stages showing the incurvation of the meganucleus about the micronucleus.

4 ( D

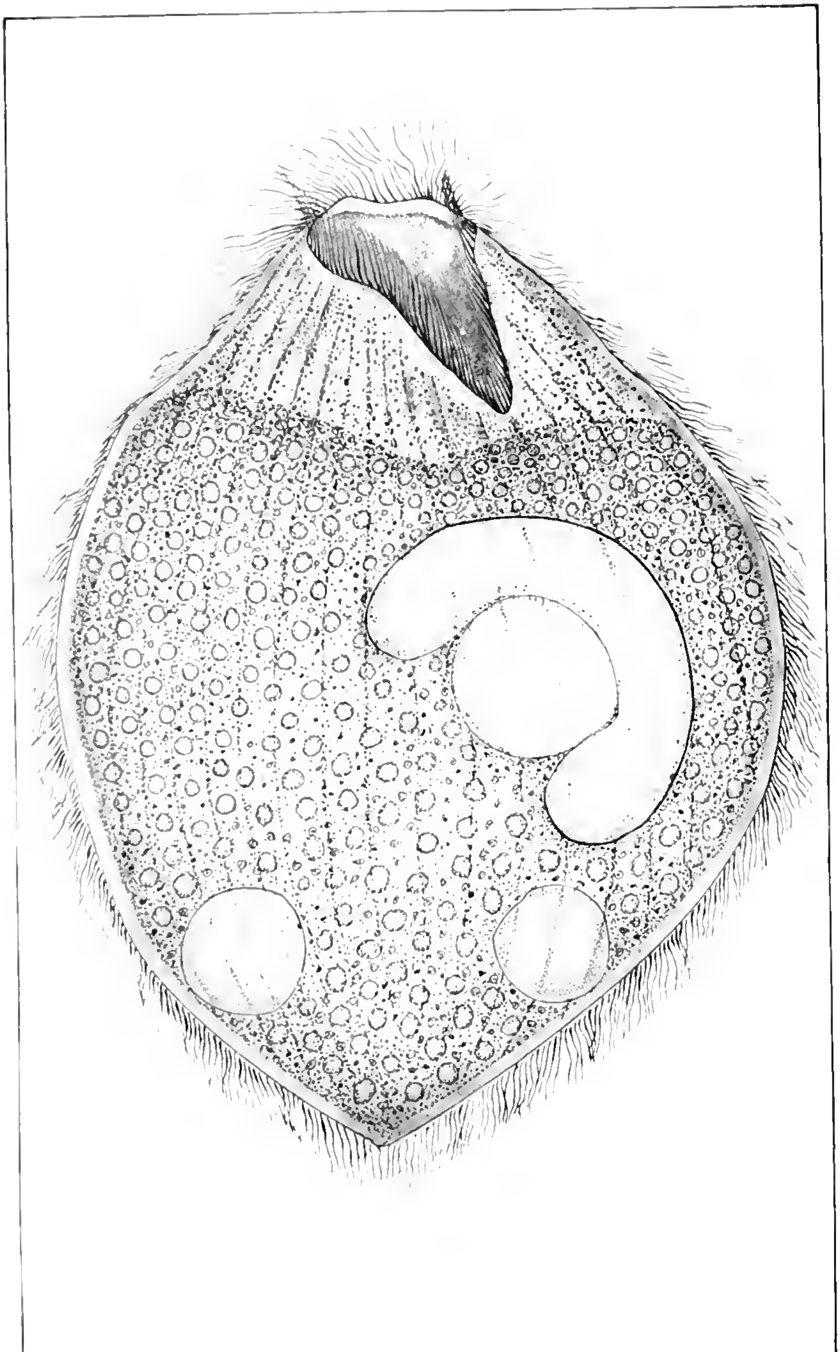


PLATE I. BALANTIDIUM HAUGWOUTI SP. NOV.

THE PHILIPPINE

# JOURNAL OF SCIENCE

VOL. XV NOVEMBER, 1919 No. 5

## FRUIT FLIES OF THE GENUS DACUS SENSU LATIORE (DIPTERA) FROM THE PHILIPPINE ISLANDS

By M. BEZZI

*Of Turin, Italy*

TWO PLATES

In his paper of 1882 on the Philippine Diptera, Osten-Sacken [1] recorded only two species of *Dacus* from the Islands. One of these, *Dacus icarus* O.-S., is a trypaneid belonging to the very different genus *Callistomyia* Bezzi, 1913. The other, "*Dacus ferrugineus* (Wied.) Macq.," is evidently a complex of several species of the true genus *Dacus sensu latiore*, which may belong to one or another of the forms here now distinguished under the names of *Chaetodacus dorsalis*, *C. occipitalis*, *C. pedestris*, *C. limbiferus*, *C. scutellinus*, and *C. pubescens*.

In my studies on Philippine Diptera I,[2] the following four species are recorded: *Chaetodacus caudatus* Fabr., *C. cucurbitae* Coq., *C. ferrugineus pedestris* Bezzi, and *Monacrostichus citricola* Bezzi; to which I subsequently added [3] *Chaetodacus scutellinus* Bezzi, *Mellesis peduneulata* Bezzi, and *M. nummularia* Bezzi.

Through the kindness of Prof. C. F. Baker, of the University of the Philippines, Los Baños, and of Mr. R. C. McGregor, of the Bureau of Science, Manila, I have received rich material of fruit flies of the genus *Dacus sensu latiore*, from the Philippine Islands. With this material at hand, we now have a better knowledge of the systematic relationships and of the distribu-

[1] Ber. Ent. Zeitschr. **26** (1882) 83–120 and 187–252; vide 224–226.

[2] Philip. Journ. Sci. § D **8** (1913) 305–332; vide 321–324.

[3] Bull. Ent. Research **7** (1916) 99–121; vide 113, 115.

tion of these flies, which, notwithstanding their immense economic importance, are still imperfectly known for the Oriental fauna.

I have already indicated [4] the main characters of the Oriental Dacinæ in opposition to those of the Ethiopian Region. I will attempt here to give an idea of the Philippine Dacinæ in relation to those of the rest of the Oriental Region. For this purpose I will give an enumeration of the Dacinæ known from three countries that have been most intensively investigated on this subject.

A. DACINÆ FROM INDIA, BURMA, AND CEYLON; 26 SPECIES

*Dacus longistylus* Wied.
*Dacus brevistylus* Bezzi.
*Dacus asiaticus* Silvestri.
*Chaetodacus ferrugineus* Fabr.
*Chaetodacus ferrugineus dorsalis* Hend.
*Chaetodacus ferrugineus incisus* Walk.
*Chaetodacus ferrugineus versicolor* Bezzi.
*Chaetodacus zonatus* W. W. Saund.
*Chaetodacus tuberculatus* Bezzi.
*Chaetodacus correctus* Bezzi.
*Chaetodacus duplicatus* Bezzi.
*Chaetodacus diversus* Coq.
*Chaetodacus maculipennis* Dol.
*Chaetodacus hageni* de Meij.
*Chaetodacus diversus* Coq.
*Chaetodacus caudatus* Fabr.
*Chaetodacus garciniae* Bezzi.
*Chaetodacus scutellarius* Bezzi.
*Chaetodacus biguttatus* Bezzi.
*Chaetodacus bipustulatus* Bezzi.
*Chaetodacus scutellaris* Bezzi.
*Mellesis sphaeroidalis* Bezzi.
*Mellesis brachycera* Bezzi.
*Mellesis crabroniformis* Bezzi.
*Mellesis destillatoria* Bezzi.
*Mellesis eumenoides* Bezzi.

B. DACINÆ FROM JAVA; 14 SPECIES.

*Bactrocera umbrosa* Fabr.
*Bactrocera albistrigata* de Meij.
*Chaetodacus impunctatus* de Meij.
*Chaetodacus obscuratus* de Meij.
*Chaetodacus dorsalis* Hend.
*Chaetodacus apicales* de Meij.
*Chaetodacus hageni* de Meij.
*Chaetodacus caudatus* Fabr.
*Chaetodacus cucurbitae* Coq.
*Chaetodacus maculipennis* Dol.
*Chaetodacus limbipennis* Macq.
*Chaetodacus ritsemae* Wey.
*Mellesis longicornis* Wied.
*Mellesis conopoides* de Meij.

C. DACINÆ FROM FORMOSA; 9 SPECIES

*Chaetodacus cilifer* Hend.
*Chaetodacus caudatus nubilus* Hend.
*Chaetodacus ferrugineus dorsalis* Hend.
*Chaetodacus scutellatus* Hend.
*Chaetodacus synnephes* Hend.
*Chaetodacus cucurbitae* Coq.
*Chaetodacus parvulus* Hend.
*Chaetodacus* sp. *a* Hend.
*Chaetodacus* sp. *b* Hend.

D. DACINÆ FROM THE PHILIPPINES; 23 SPECIES

*Bactrocera umbrosa* Fabr.
*Chaetodacus atrichus* sp. nov.
*Chaetodacus atrichus davaoanus* var. nov.
*Chaetodacus ablepharus* sp. nov.
*Chaetodacus ablepharus mindanaus* var. nov.
*Chaetodacus ferrugineus dorsalis* Hend.
*Chaetodacus ferrugineus occipitalis* var. nov.
*Chaetodacus ferrugineus pedestris* Bezzi.

[4] Bull. Ent. Research 6 (1915) 85–101; vide 85, 86.

*Chaetodacus ferrugineus limbiferus* var. nov.
*Chaetodacus continuus* sp. nov.
*Chaetodacus mcgregori* sp. nov.
*Chaetodacus bakeri* sp. nov.
*Chaetodacus cucurbitae* Coq.
*Chaetodacus caudatus* Fabr.
*Chaetodacus mundus* sp. nov.
*Chaetodacus tetrachaetus* sp. nov.
*Chaetodacus scutellinus* Bezzi.
*Chaetodacus pubescens* sp. nov.
*Mellesis subsessilis* sp. nov.
*Mellesis bioculata* sp. nov.
*Mellesis pedunculata* Bezzi.
*Mellesis nummularia* Bezzi.
*Monacrostichus citricola* Bezzi.

From the above enumerations it is to be seen that *Chaetodacus dorsalis*, *C. cucurbitae*, and *C. caudatus* are common to the four countries; while *C. maculipennis* and *C. hageni* are common to India and Java, and *Bactrocera umbrosa* is common to Java and the Philippines. Of the three widely spread species *C. f. dorsalis* is the commonest representative of the *ferrugineus* group, which is the eminently characteristic *Chaetodacus* from the Orient; *C. cucurbitae* and *C. caudatus* are widely distributed over the region as well as over the islands of the Pacific Ocean, probably in connection with man and commerce. The other species are in great probability endemic; but even among these attention must be given to the forms spread by man.

The descriptions of the following species have been carefully compared, but have been found different:

*frauenfeldi* Schiner, 1868, from the Stuart Islands.
*xanthodes* Brown, 1904, bred in New Zealand from fruits of various kinds imported from Fiji.
*cucumis* French, 1907, bred in New South Wales from cucumbers imported from Queensland.
*ornatissimus* Froggatt, 1909, bred at Sydney, New South Wales, from mandarins imported from New Caledonia.
*curvipennis* Froggatt, 1909, bred at Sydney, New South Wales, from bananas imported from Fiji.
*aequalis* Coquillett, 1909, bred from larvæ in oranges at Gosford, New South Wales.
*melanotus* Coquillett, 1910 (=*rorotangae* Froggatt, 1910), bred from mangoes in the Cook Islands.
*facialis* Coquillett, 1910, bred from guavas in the Tonga Islands.
*virgatus* Coquillett, 1910, bred from guavas in the Tonga Islands.
*pepisalae* Froggatt, 1910, from the Solomon Islands.
*passiflorae* Froggatt, 1910, bred from mangoes in Fiji.
*tongensis* Froggatt, 1910, bred from mangoes in the Tonga Islands.
*kirki* Froggatt, 1910, bred from peaches and other fruits imported into New Zealand.
*froggatti* nom. nov. for *zonatus* Froggatt, 1910 (not of W. W. Saunders, 1841), from Solomon and Murray Islands.
*chrysotoxus* Hendel, 1912, from Key Island.

Most of the very numerous species of "*Dacus*" described by Walker from the Malay Archipelago belong to other genera of

the Trypaneidæ or of the Ortalidæ;[5] it seems that the following only may properly belong to *Chaetodacus:*

*discipennis* Walker, 1861, from Batjan; seems to be near *chrysotoxus* Hend.
*terminifer* Walker, 1860, from Macassar; closely allied to *cilifer* Hend. and to *ablepharus* Bezzi.
*diffusus* Walker, 1860, from Macassar; seems to be allied to *maculipennis* Dol.
*emittens* Walker, 1860, from Celebes; seems to belong to the *ferrugineus* group.
*absolutus* Walker, 1861, from Ceram; seems to be allied to *ferrugineus* Fabr.
*expandens* Walker, 1859, from the Aru Islands, seems to be very near *ferrugineus* Fabr.
*pectoralis* Walker, 1859, from Aroe, Batjan, and Waigoe; seems to be closely allied to *ferrugineus* Fabr.

As an example of the richness and the great variety of the Philippine fauna in *Dacus* species, it may be recorded that on the small island of Batbatan,[6] Antique Province, Panay, Mr. McGregor procured in a single collection, consisting of thirty specimens, no less than eight forms of *Chaetodacus,* seven of which are new to science, as follows:

*Chaetodacus atrichus* sp. nov., 2 males and 1 female.
*Chaetodacus ferrugineus occipitalis* var. nov., 6 males and 1 female.
*Chaetodacus ferrugineus pedestris* Bezzi, 2 females.
*Chaetodacus ferrugineus limbiferus* var. nov., 2 males and 5 females.
*Chaetodacus continuus* sp. nov., 1 female.
*Chaetodacus mcgregori* sp. nov., 1 male and 1 female.
*Chaetodacus mundus* sp. nov., 6 males.
*Chaetodacus tetrachaetus* sp. nov., 2 males.

The genera of the true Dacinæ at present known can be distinguished with the aid of the following key which is a complement of that already given by me.[7] It must be remarked

[5] See my critical enumeration, Memoirs Ind. Mus. 3 (1913) 65–84.

[6] Batbatan Island lies 16 kilometers west of Culasi Point and has an area of about 770 hectares. The shores are precipitous coral rock, and there are few landing places. Nearly the entire island is 10 to 20 meters above the sea; the highest point has an elevation of about 120 meters. The soil is everywhere poor and thin. Considerable rice and a few coconuts and bananas are cultivated; the native vegetation is scanty and consists of plant species that are common on Panay. The flies described in this paper as from Batbatan Island were caught in the small town at the flowers of hedges of *Jatropha curcas* Linn., during a week of typhoon weather, June 24 to 30, 1918. Doctor Bezzi has requested me to add this note.—McGregor.

[7] Philip. Journ. Sci. § D 8 (1913) 323.

that the genera *Dacus sensu stricto*, *Tridacus*, *Tetradacus*, and *Callantra* have not yet been found in the Philippine Islands.

a¹. Antennæ as long as face or only a little longer, carried very near the face and with first joint not elongate, even shorter than second; face hollowed in the middle; abdomen not properly stalked, though sometimes a little constricted at base; second basal cell short, usually not more than twice as long as broad.

b¹. Thorax without prescutellar bristles; scutellum with a single pair of bristles, the basal one being always wanting.

c¹. Wings of male without supernumerary lobe at end of anal vein.

d¹. Thorax with only two supra-alar bristles, the anterior one being quite wanting; abdomen often with no distinct segmentation along middle line; anal brown stripe of wings less developed or wanting; Mediterranean or Ethiopian species .. Dacus s. s.

d². Thorax with three or four supra-alar bristles, the anterior ones well developed; abdomen as a rule with free segments on the middle.

e¹. Thorax with but one anterior supra-alar bristle; anal brown stripe of wings usually well developed; ovipositor not peculiarly swollen at base; Ethiopian .... Tridacus Bezzi.

e². Thorax with two anterior supra-alar bristles; no anal stripe on wings; ovipositor greatly swollen, bottle-shaped at base; Japanese .... Tetradacus Miyake.

c². Wings of male with a well-developed supernumerary lobe; abdominal segments free; anal brown stripe of wings well developed; Oriental .... Chaetodacus p. p.

b². Thorax always provided with prescutellar and with anterior supra-alar bristles; scutellum sometimes with two pairs of bristles, the basal pair often present; wings of male, as a rule, with a well-developed supernumerary lobe; Oriental.

f¹. Wings adorned with transverse, fuscous bands.
Bactrocera Guér.-Mén.

f². Wings not banded.... Chaetodacus Bezzi.

a². Antennæ much longer than face, carried far apart from it and with the first joint usually elongate, as long as second; face not or little hollowed, usually flat or even convex; abdomen typically stalked, club-shaped; thorax without prescutellar bristles; femora sometimes spinose beneath; wings with second basal cell more elongate, usually many times longer than broad, and without supernumerary lobe in the male; Oriental.

g¹. Basal joints of antennæ wholly separated.

h¹. Face flat or even a little concave; thorax with transverse suture broadly interrupted in the middle and destitute of unpaired acrostical bristles; front femora not spinose beneath or very rarely so; second portion of fourth longitudinal vein straight, the discoidal cell being less narrowed at base .... Mellesis Bezzi.

h². Face distinctly convex; thorax with transverse suture not interrupted and often with a strong acrostical bristle on the middle line; front femora with some spines beneath near the end; second portion of fourth

vein deeply sinuous, the discoidal cell being thus much narrowed on the basal half ..... **Monacrostichus** Bezzi.

*g*. Basal joints of antennæ united in the shape of a common petiole ..... **Callantra** Walk.[8]

The first three genera, as far as known, are not represented in the Philippines. *Dacus* and *Tridacus* are not Oriental; the two species of true *Dacus* found in India (*longistylus* Wied. and *brevistylus* Bezzi) are evidently of African origin; *Dacus asiaticus* Silvestri[9] is only a variety of the Mediterranean *D. oleae* Gmelin; but the presence of true Oriental forms lacking prescutellar bristles is demonstrated by the two Philippine species described below; and moreover by the recently described *Tetradacus tsuneonis* Miyake,[10] from Japan, as well as by the Australian *Dacus cucumis* French, which lacks also the anterior supra-alar bristle.

The Philippine species without prescutellar bristles (*atrichus* and *ablepharus*), are evidently more closely allied to *Chaetodacus* than to *Tridacus*, as shown by their sexual wing dimorphism, and by their close affinity with *cilifer* Hendel, which has well-developed scutellar bristles. They have no close affinity with the African species of *Dacus sensu stricto*, like *annulatus*, *mochii*, *blepharogaster*, *erythraeus*, etc., which usually have a nonciliated third abdominal segment in the male and are likewise prevalently black and of a rather small size, but all have no anterior supra-alar bristle, partly fixed abdominal segments, and no brown anal stripe on the wings. A possibility of an African origin for these Philippine species seems thus to be excluded.

### I. Genus BACTROCERA Guérin-Méneville (1830) 1838

It seems that, for practical purposes, it is still convenient to keep the species with banded wings separate from those with nonbanded wings and thus the following genus is maintained here as distinct; but if the two species with a single crossband on the wings (*frauenfeldi* Schiner and *albistrigata* de Meijere) are placed in the present genus, and if the recently discovered African species of *Dacus sensu stricto* with partly banded wings (*hamatus* Bezzi and *trigonus* Bezzi) are taken into consideration, the separation of the two genera seems to be very doubtful.

[8] The genus *Diplochorda* Osten-Sacken, 1880, placed in the Dacinæ by Hendel, 1911, and by Edwards, 1915, is now considered as belonging to the Phytalmiidæ by Hendel himself, Wien. ent. Zeitung **33** (1914) 74, note.

[9] Atti R. Accad. dei Lincei, Roma V **25** (1916) 425.

[10] Bull. Imp. Central Agr. Exp. Sta. Japan **2** (1919) 92, pl. 2, fig. 1.

1. Bactrocera umbrosa Fabricius, 1805.

Of this widely spread Oriental species, which I have selected as the type of the genus *Bactrocera sensu stricto*, there are specimens from the following localities: LUZON, Laguna Province, Mount Maquiling (*C. F. Baker*). MINDANAO, Butuan and Davao (*Baker*).

The species has been described several times under different names, of which *Dacus fascipennis* Wiedemann, 1819, from Java; *Bactrocera fasciatipennis* Doleschall, 1856, from Java; and *Strumeta conformis* Walker, 1857, from Singapore, are commonly considered as synonyms; but even *Dacus frenchi* Froggatt, 1909, from New Caledonia and Australia, is certainly the same species, in as much as Froggatt [11] records later that it was bred in Java from fruits of *Artocarpus integrifolia* by Roepke.

Another question is that concerning the original *Bactrocera longicornis* of Guérin-Méneville (1830) 1838; in 1835 Macquart gave a figure of the wing that is very different from the wing of *umbrosa*, showing the two middle dark bands confluent toward the hind border of the wing; moreover, the scutellum is described as having a black spot above in the middle.

## II. Genus CHAETODACUS Bezzi, 1913

The rather numerous Philippine species of *Chaetodacus* can be distinguished as follows:

*a*¹. Third and fourth abdominal segments entirely black or each with a complete and broad, transverse black band; no middle longitudinal black stripe on these segments; oval patches of last segment black; occiput black, with a narrow yellow border; species of smaller size.

- *b*¹. No prescutellar bristles; third abdominal segment of male not ciliated.
  - *c*¹. Abdomen reddish, with three complete black crossbands; black oval patches of last segment very striking, contrasting with the reddish color of the surrounding parts.
    - *d*¹. Frons black-spotted; face of male entirely black; face of female with three black spots, the upper one placed just below root of antennæ of smaller size .................... C. atrichus sp. nov.
    - *d*². Frons unspotted; face of female with the two lower black spots alone; of greater size .................... C. davaoanus var. nov.
  - *c*². Abdomen entirely black, even the black oval patches of the last segment being indistinguishable.
    - *e*¹. A well-developed black crossband at vertex; face in both sexes with a broad black band on lower half. C. ablepharus sp. nov.
    - *e*². Black vertical band less distinct or even wanting; face of female with two black spots .................... C. mindanaus var. nov.

[11] Proc. Linn. Soc. N. S. W. 35 (1910) 866.

$b^3$. Prescutellar bristles well developed; third abdominal segment of male ciliated; face of male with two black bands, that of female with two black spots .......... C. cilifer Hend.[12]

$a^2$. Fourth abdominal segment without complete black crossband or, rarely, with a very narrow one; last two segments of abdomen with a black longitudinal middle stripe; oval patches of last abdominal segment never black; species of greater size.

$f^1$. Scutellum with but a pair of bristles, the apical one.

$g^1$. Two pairs of lower fronto-orbital bristles; hind cross vein not broadly margined with fuscous; mesonotum without a bright yellow postsutural middle stripe.

$h^1$. Costal dark border of wing not much dilated at end and not reaching fourth vein apically; frons narrow; third abdominal segment of male ciliated (in one species the male is unknown).

$i^1$. Face with the usual two black spots; no anal bulla on wings.

$j^1$. Yellow lateral stripes of mesonotum broadly interrupted before suture; anal brown stripe of wings well developed.

$k^1$. Vertical, thoracic, and scutellar bristles pale yellowish; occiput reddish; mesonotum partly reddish on breast and on pleura; mesophragma reddish in the middle; femora and tibiæ entirely reddish; costal border of wings narrow and rather pale.......... C. dorsalis Hend.

$k^2$. The above-named bristles more or less darkened or even blackish; mesonotum and mesophragma entirely black; tibiæ black, at least those of hind pair of legs; costal border broader and more intensely black.

$l^1$. Costal border toward middle not extending beyond second longitudinal vein or only a little so, the submarginal cell being in greatest part hyaline or only yellowish.

$m^1$. Occiput reddish, with more or less distinct fuscous spots in the middle; femora entirely yellowish or only those of front pair of legs darkened at end on the outer side; submarginal cell often yellowish below costal border; of greater size.

C. occipitalis var. nov.

$m^2$. Occiput black in the middle, with reddish borders; all femora more or less blackened at ends; submarginal cell quite hyaline below costal border; of smaller size.

C. pedestris Bezzi.

$l^2$. Costal border extending to third longitudinal vein, submarginal cell being thus filled entirely

[12] From Formosa, included here for comparison only.

with brown; occiput usually reddish; femora blackened at ends; size as in *occipitalis*.

C. limbiferus var. nov.

$j^2$. Yellow lateral stripe of mesonotum extending, without interruption, from humeri to postalar calli; anal brown stripe of wings less developed; frons narrow and unspotted; bristles black; costal border rather dilated at end, but not extending in the middle beyond second longitudinal vein.

C. continuus sp. nov.

$i^2$. Face unspotted; no brown anal stripe, but in male a peculiar anal bulla on wing; frons narrow and unspotted; bristles black; costal border narrow and not dilated at end ........................ C. mcgregori sp. nov.

$h^2$. Costal border narrow, but suddenly dilated at end to form a broad apical spot, which reaches below fourth vein; frons unspotted and broad, about as broad as long; anal stripe developed; third abdominal segment of male not ciliated............................ C. bakeri sp. nov.

$g^2$. Three pairs of lower fronto-orbital bristles; mesonotum reddish, with a bright yellow middle stripe beyond the suture; hind cross vein broadly margined with fuscous.

C. cucurbitae Coq.

$f^2$. Scutellum with two pairs of bristles, the basal and the apical being equally developed; mesonotum with a bright yellow, postsutural middle stripe.

$n^1$. Scutellum entirely yellow.

$o^1$. Face without black spots; hind cross vein and hind border of third posterior cell margined with fuscous; three lower orbital bristles.

C. mendus sp. nov.

$o^2$. Face with the usual two black spots; third posterior cell without fuscous border.

$p^1$. Three lower orbital bristles; anal brown stripe developed; costal border dilated at end; mesonotum reddish in front of suture.

C. caudatus Fabr.

$p^2$. Two lower orbital bristles only; no distinct anal stripe; costal border not dilated at end; mesonotum black in front of suture.

C. tetrachaetus sp. nov.

$n^2$. Scutellum with a well-defined black spot at end, between apical bristles; brown anal stripe of wings broad.

$q^1$. Two lower orbital bristles only; back of mesonotum black; femora

black-spotted; costal border of wings not dilated at end.
C. scutellinus Bezzi.

$q^2$. Three lower orbital bristles; back reddish in front; femora not black-spotted; costal border dilated at end **C. pubescens** sp. nov.

2. Chaetodacus atrichus sp. nov. Plate I, fig. 1.

A small species, destitute of prescutellar bristles, very distinct on account of the complete black bands of the abdomen, the entirely black face of the male, and the nonciliated third abdominal segment in the same sex.

PANAY, Antique Province, Batbatan Island (*R. C. McGregor*). Types in my collection.

*Male and female*.—Length of body, 4.5 to 5 millimeters; of wing, 4.4 to 4.8. Occiput shining black, with a complete yellow border, which is a little dilated below. Frons about twice as long as broad; dull yellow, with rather shining, a little paler orbits; a dark middle spot and two dark spots on each side, one at the superior and one at the second of the lower orbital bristles; ocellar dot shining black and at its sides a dark spot, thus forming a more or less distinct vertical crossband; lunula small, shining reddish brown. Antennæ a little longer than face, first joint short; entirely reddish, third joint a little infuscated above and at the end; crista reddish at base. Face shining, hollowed in the middle; in the male entirely black, only the external half of antennal grooves yellowish like the linear cheeks; in the female pale yellowish, with three black spots, two near mouth border at inner end of antennal grooves and the third just below root of antennæ. Jowls narrow, reddish brown, with a small dark subocular spot. Palpi and proboscis reddish, the latter darkened above. Cephalic bristles black; only two pairs of lower orbital bristles present.

Mesonotum entirely black and rather dull on the back on account of its punctulation and its short, gray pubescence; smooth and shining on the pleura; breast with whitish hairs. Whitish yellow markings broad and disposed as follows: Humeri entirely; notopleural calli; a broad stripe on each side above root of wings, continued in front of suture with a small spot, and abbreviated behind before reaching scutellum; a broad, triangular spot on mesopleuron, which ends with a small spot on the upper part of sternopleuron; a double, contiguous hypopleural spot. Scutellum entirely whitish yellow, with only the apical pair of bristles. Mesophragma entirely black like back

of mesonotum. Thoracic bristles black; scapular bristles well developed, even the middle pair; one anterior supra-alar; no prescutellar; pteropleural a little weaker than the mesopleural. Squamulæ darkish; halteres whitish.

Abdomen broad and rounded, punctate and pubescent like back of mesonotum; yellowish, with broad, black crossbands; first segment broadly black at base and on sides; second segment with a complete transverse black band at base; third and fourth segments each with a complete, black, basal crossband, in the male equal in breadth to half the segment, in the female much broader, only a narrow hind border being yellow; fifth segment with a black fore border, interrupted in the middle and more developed in the female; black oval patches less shining on account of their punctulation, and in the female a black middle stripe between them. Venter with yellowish membrane, anterior sternites brown and posterior ones black; male genitalia black, with yellowish appendages, anterior one forked at base; ovipositor flat, with basal segment black and apical segment reddish brown; legs with blackish or dark brown coxæ and trochanters; femora yellow, with a more or less broad black patch before the end; all tibiæ yellow in the male, in the female four posterior ones black with yellowish bases; tarsi whitish in both sexes.

Wings (Plate I, fig. 1) hyaline, with a blackish fore border and a blackish anal stripe. Costal border formed by the stigma, by the black marginal cell not surpassing second longitudinal vein, and by a little broader (but not spotlike) border at end of submarginal cell and of first posterior cell, ending a little beyond middle of apex of first posterior cell. Anal stripe broad and intensive, but not dilated at end, and bearing no bulla in the male. First basal cell darkened just above dilated second basal cell. Last portion of fourth vein nearly straight.

*Note.*—In the abdominal pattern the present species recalls *Chaetodacus scutellatus* Hendel, from Formosa, or *C. bezzi* Miyake, from Japan, which however are much larger and have prescutellar bristles.

3. **Chaetodacus atrichus davaoanus** var. nov.

Differing from the preceding species in greater size and in some minor details of color pattern.

MINDANAO, Davao (*Baker*). Type in Professor Baker's collection.

*Female.*—Length of body, 6 millimeters; of wing, 5.5. The

frons is quite unspotted, excepting the black ocellar dot; the face lacks the upper black spot; the episternal callosities are broadly yellowish; the black abdominal band lacks the middle point on that of the third segment, and there is no black stripe between the two black patches of the last segment; the basal segment of the ovipositor is reddish brown.

4. **Chaetodacus ablepharus** sp. nov. Plate I, fig. 2.

Very much like the preceding species (*C. atrichus*), but at once distinguished by the entirely black abdomen.

LUZON, Tayabas Province, Malinao (*Baker*): Laguna Province, Mount Banahao (*Baker*). Types in Professor Baker's collection.

*Male and female.*—Length of body, 4.5 millimeters; of wing, 4.3. Head as in the preceding, but yellow occipital border narrower; at vertex a small but distinct transverse black band. including black ocellar dot; face in both sexes with a black crossband. extending on its lower half. Mesonotum and scutellum as in the preceding, but back distinctly more shining; supra-alar stripe narrower and ending at suture, presutural spot before it being quite wanting. Halteres whitish. Abdomen as in the preceding but completely black, only the extreme hind border at last segment being narrowly reddish in the male; male genitalia and ovipositor entirely black. Legs as in the preceding, but femora more broadly and more intensely black; posterior tibiæ blackish in the male and all tibiæ black in the female. Wings (Plate I, fig. 2) as in the preceding; marginal cell a little subhyaline in the middle, the costal border being thus even narrower, thin fringe at hind border of axillary lobe longer than in the preceding species; supernumerary lobe of the male more exaggerated.

*Note.*—The present species is closely allied to *Chaetodacus cilifer* Hendel, from Formosa, which, however, has prescutellar bristles and a ciliated third abdominal segment in the male. It is always a question which of the species *C. ablepharus* and *C. cilifer* may or may not be the same as *C. terminifer* Walker, from Macassar.

5. **Chaetodacus ablepharus mindanaus** var. nov.

Distinct from the species in some minor details of the pattern of the head.

MINDANAO, Davao (*Baker*). Type in Professor Baker's collection.

*Female.*—Differs only in the want of the black crossband

at vertex; and in the face, which has only two black spots, of elongate shape, at the lower end of the antennal grooves.

6. Chaetodacus ferrugineus dorsalis Hendel, 1912.

This is the palest-colored form among those separated from *C. ferrugineus;* it seems to be rather rare in the Philippines, being represented by a single female specimen.

LUZON, Laguna Province, Los Baños (*Baker*).

7. Chaetodacus ferrugineus occipitalis var. nov. Plate I, fig. 3.

*Male and female.*—This new variety is darker colored than the preceding one, having darkened bristles, black mesonotum, black mesophragma, and black tibiæ; but it is paler colored than the following one, having reddish occiput and entirely yellowish femora. The dark fore border of the wing (Plate I, fig. 3) is broader than in *C. dorsalis* and *C. pedestris;* it is usually continued by a yellowish tint into the middle of the submarginal cell. The length varies from 7 to 8 millimeters. It seems to be the commoner form in the Philippines.

LUZON, Laguna Province, Los Baños, Mount Maquiling and Mount Banahao (*Baker*): Rizal Province, Manila (*McGregor*). PANAY, Antique Province, Batbatan Island (*McGregor*). MINDANAO, Davao (*Baker*). Types in Professor Baker's collection. Specimens taken at Singapore by Professor Baker agree with this variety.

*Note.*—In all these three forms (*C. f. occipitalis, pedestris,* and *limbiferus*) the oval patches of the fifth abdominal segment are shining reddish, like the surrounding parts.

8. Chaetodacus ferrugineus pedestris Bezzi, 1913. Plate I, fig. 4.

*Male and female.*—In the present variety the occiput is black in the center, with a yellow border on the sides; the bristles are nearly black; the submarginal cell (Plate I, fig. 4) is quite hyaline below the costal border, which does not surpass the second longitudinal vein in the middle or only a little so. The length varies from 6 to 7 millimeters, rarely surpassing 7 millimeters in the female.

It is probable that the present form is the *ferrugineus* recorded by Osten-Sacken, being very common near Manila. It is closely allied to the common Indian form that I have described under the name *C. ferrugineus incisus* Walker, but may be distinguished by the much broader yellow supra-alar stripe of mesonotum and the less-blackened abdomen.

LUZON, Laguna Province, Los Baños (*Baker*) : Rizal Province,

Manila (*McGregor*). PANAY, Antique Province, Batbatan Island (*McGregor*).

9. **Chaetodacus ferrugineus limbiferus** var. nov. Plate I, fig. 5.

*Male and female.*—This new variety is allied to *C. pedestris* in the color of the legs and of the bristles and to *C. occipitalis* in the color of the occiput; but differs from both in the very broad black fore border of the wings (Plate I, fig. 5), which extends equally broadly to the third longitudinal vein. The length varies from 7 to 8 millimeters.

PANAY, Antique Province, Batbatan Island (*McGregor*). Types in my collection.

10. **Chaetodacus continuus** sp. nov. Plate I, fig. 6.

Allied to the preceding forms of *C. ferrugineus sensu latiore*, but distinct from them as well as from all the other species here recorded, on account of the yellow lateral stripe of mesonotum being continued, without interruption, from the humeri to the postalar calli.

PANAY, Antique Province, Batbatan Island (*McGregor*). Type in my collection.

*Female.*—Length of body, 6 millimeters; of ovipositor, 1.5; of wing 5.5. Occiput shining reddish yellow, with a less-distinct fuscous, central patch. Frons proportionately narrow, more than twice as long as broad; entirely reddish yellow, unspotted, being only a little infuscated in middle of anterior half; small ocellar dot black; shining only on sides and at vertex. Lunula reddish. Antennæ entirely reddish, as long as face; third joint as narrow as usual, infuscated at end and at upper border near the end. Face concave, shining yellowish, with two elongate black spots at apical half of antennal grooves; cheeks linear, with white dust; jowls narrower than breadth of third antennal joint, not distinctly spotted. Palpi reddish; proboscis dirty brownish. Cephalic bristles black; only two pairs of lower orbital bristles.

Mesonotum with a very characteristic pattern: On the back reddish, with a short pale yellowish pubescence; finely punctulate and rather shining at sides; along the middle two opacous, whitish longitudinal stripes, separated by a narrow darkish and shining middle streak, not extending to scutellum; along dorsocentral lines two shining black longitudinal stripes, one on each side, extending from the black collar to scutellum and united there by a shining black transverse stripe; humeri wholly yellow; supra-alar yellow stripe broad and continued in front of

suture by an equally broad, slightly arched stripe, which reaches humeral spot; a black notopleural stripe, sutural callosities yellow. Pleura shining black, reddish on propleural region; mesopleuron with a broad yellow patch, continued below with a broad rounded spot on upper part of sternopleuron; a double yellow hypopleural spot; mesophragma entirely shining black. Scutellum entirely yellow with a very narrow black basal stripe; it has only the apical pair of bristles. All the bristles black; middle scapular strong, but shorter than those of outer pair; pteropleural well developed; prescutellar long; one anterior supra-alar. Squamulæ dark, with pale hairs; halteres whitish.

Abdomen rounded, with distinct segmentation, broader than thorax, reddish, finely punctulate, rather shining, with a short pale yellowish pubescence. Whole of first and second segments narrowly black on sides and with a black transverse stripe on the middle not extending to sides; hind half of second segment, beyond the transverse black stripe, paler and more yellowish; third segment black at base and on sides, forming thus a second black crossband, the latter broadened laterally and extending to the black sides; fourth and fifth segments black on sides; a black middle stripe, very narrow at the black basal border of third segment, becoming broader on fourth and fifth segments and reaching the end of the last; fifth segment entirely shining, its usual patches not distinct. Venter entirely reddish, with black borders; ovipositor entirely reddish and shining, flattened, with basal segment a little infuscated apically. Legs and coxæ pale yellowish, with hind tarsi whitish; middle tibiæ black on basal and whitish on apical half; hind tibiæ quite black; the short pubescence of legs with the color of the parts on which it occurs; spur of middle tibiæ black.

Wings (Plate I, fig. 6) hyaline and iridescent, proportionally narrow; second longitudinal vein straight; third slightly bent downward at end; last portion of fourth vein slightly curved at base; small cross vein beyond middle of discoidal cell. Pattern very simple, consisting only of a narrow brown fore border, which includes the darker stigma, extends below not beyond second longitudinal vein, fills up the end of submarginal cell and the whole end of first posterior cell, being there rather broad with an oblique inner border and reaching the end of fourth vein. Costal cells and the part of first basal cell just above the dilated second basal cell infuscated; third posterior cell slightly infuscated at base near anal cell, but there is no distinct brown anal stripe.

11. **Chaetodacus mcgregori** sp. nov. Plate I, fig. 7.

Allied to the preceding species, but distinct by the unspotted face, and strikingly characterized by the broad third antennal joint, and by the anal bulla in the wing of the male.

PANAY, Antique Province, Batbatan Island (*McGregor*). This very peculiar species is named in honor of its collector. Types in my collection.

*Male and female*.—Length of body, 5 to 5.5 millimeters; of ovipositor, 0.5; of wing, 4.5 to 5. Head and its bristles exactly as described for the preceding species, but no distinct dark patch on middle of occiput. Antennæ a little shorter than face and with third joint broader than in the allied species; very broad in the male and clothed with very long pubescence, obliquely truncate at the end; entirely yellowish. Face quite unspotted. Back of mesonotum as in the preceding, but paler, the black stripes being less developed; yellow stripe uniting humeri with supra-alar stripe less marked and interrupted in front of suture. Pleura likewise colored, but propleural region more broadly reddish; mesophragma with a reddish middle stripe. Scutellum, squamulæ, and halteres as in the preceding. Bristles black, but scapular, mesopleural, and pteropleural yellowish.

Abdomen as in the preceding, but first two segments without black sides; black middle longitudinal stripe present only on the last two segments, being quite wanting on third; in the female the fourth segment with a narrow black basal band, which is wanting in the male; sides of last three segments black spotted in both sexes; oval patches of fifth segment indistinct in both sexes. Third segment of male ciliated; ovipositor very short and entirely of a pale reddish color. Legs as in the preceding, but even paler, the middle tibiæ being quite yellowish and the hind tibiæ being only darkened, not properly black.

Wings (Plate I, fig. 7) as in the preceding, but distinctly broader. Costal border equally shaped, but paler and more equal throughout, being not at all dilated at end of first posterior cell; stigma much paler; costal cell quite hyaline; first basal cell only a little infuscated above second basal one; anal stripe less indicated in the female, in the male replaced by a shining, sharply separated bulla of a yellowish color, placed just above the prolongation of the anal cell, on its terminal half. Supernumerary lobe of male not much developed.

12. **Chaetodacus bakeri** sp. nov. Plate I, fig. 8.

A rather robust species, with an almost stalked abdomen,

distinct from all the other species with two scutellar bristles on account of the broad, apical fuscous spot of the wings.

MINDANAO, Davao, a male specimen belonging to Prof. C. F. Baker, in whose honor it is named.

*Male*.—Length of body, 6.5 millimeters; of wing, 6. Occiput rather convex, shining yellowish, reddish toward middle. Frons very broad, about as broad as long, entirely reddish yellow, unspotted, with a blackish, transverse, vertical stripe, including the black ocellar spot; opacous. Lunula broad, yellowish. Antennæ as long as face, with a short first joint; entirely yellowish, with a narrow third joint. Face concave, shining yellow, with black spots at end of antennal grooves. Cheeks whitish; jowls as broad as breadth of third antennal joint, with a reddish subocular spot. Palpi reddish; proboscis dirty brown. Cephalic bristles black; only two lower orbital bristles.

Back of mesonotum reddish, roughly punctulate, a little shining, with a short pale pubescence; black markings as follows: A narrow middle stripe, ending at suture; a triangular patch on each side before suture, with base on dorsocentral line and vertex on notopleural line just behind humeral callosities; a broad patch on each side behind suture, reaching with its acute point the base of scutellum; a narrow transverse stripe just in front of scutellum. Pleura reddish, with broad black patches around the yellow markings. Yellow markings as follows: Humeral calli entirely; presutural calli, and extending from them a short triangular spot near suture; a narrow and less striking supra-alar stripe; a broad mesopleural stripe, continued below into a broad spot on upper part of sternopleuron; a double hypopleural spot. Mesophragma black, but reddish toward the middle and above. Scutellum convex, punctulate, yellowish, with a very narrow basal black stripe; with only the apical pair of bristles. Thoracic bristles black, but dropped out in the case of the type. Squamulæ and halteres whitish.

Abdomen very convex in the middle and restricted at base, but not properly stalked; segmentation very evident; reddish, punctulate, and pubescent like back of mesonotum; first and second segments more yellowish, and black at base and on sides, black crossband of second segment not extending to sides; third segment with black transverse band at base, dilated on a black lateral border at sides, and moreover with the narrow black longitudinal middle stripe, forming with those of fourth and fifth segments a longitudinal stripe, narrowly interrupted at sutures

and ending a little before hind border of last segment. Last two segments with a broad black patch on each side, in the shape of a lunate spot, chiefly those of the fourth segment; oval patches of fifth segment less indicated and nearly opaceous. Venter entirely reddish yellow, only the pregenital plate being blackish. Hind border of third segment with black cilia on sides. Legs and coxæ reddish yellow, with tarsi whitish at base; short pubescence whitish, middle spur black; four anterior tibiæ more or less darkened outwardly and at base; hind tibiæ blackish, with a broad prominent tubercle at hind side before the end.

Wings (Plate I, fig. 8) hyaline, very iridescent and shining; veins reddish; second longitudinal vein straight, short and very close to costa, the marginal cell being as narrow as stigma; third vein rather sinuous, curved above before its end; terminal portion of fourth vein very little curved at base; small cross vein very long, placed about on middle of discoidal cell, the latter less regular than usual, being a little restricted above on its basal half; supernumerary lobe not much developed. The pattern consists of a very narrow costal border, including the stigma and the very narrow marginal cell; at distal end of this border and narrowly united with it, a very broad, rounded, blackish spot at ends of submarginal and first posterior cells. Costal cells quite hyaline, first basal darkened above the second. Anal stripe well developed, and apparently broadened at end of the joint of anal cell.

*Note.*—The present species, because of its broad frons, the restricted base of its abdomen, and its wing pattern, recalls some species of the genus *Mellesis* with shortened first antennal joint, like *M. brachycera* Bezzi, from India; but it seems that the anterior supra-alar bristles as well as the prescutellar bristles are present.

13. **Chaetodacus cucurbitae** Coquillett, 1899.

This is well distinguished from all the other species by the three pairs of lower orbital bristles, the middle yellow stripe of the back of mesonotum, and the peculiar wing pattern with the broadly infuscated hind cross vein.

LUZON, Laguna Province, Los Baños and Mount Maquiling (*Baker*). MINDANAO, Davao (*Baker*). These insular specimens are a little smaller than the continental ones (from India), measuring usually not over 6 to 6.5 millimeters in length.

14. **Chaetodacus caudatus** Fabricius, 1805.

The Philippine specimens of the present species are very much

like those of the preceding one, but they are at once distinguished by the larger size, the black patches of the back of mesonotum, the four scutellar bristles, and the hind cross vein of the wings being not bordered with fuscous. In the last character they agree with the variety *C. c. nubilus* Hendel, from Formosa; but as I have said in another place,[13] I have never seen specimens with broadly infuscated hind cross vein, in opposition to what is stated by de Meijere.[14] The Philippine specimens with infuscated cross vein belong to the next, very distinct species, *C. mundus*.

LUZON, Laguna Province, Los Baños, Mount Maquiling, and Mount Banahao (*Baker*): Nueva Vizcaya Province, Imugan (*Baker*).

15. **Chaetodacus mundus** sp. nov. Plate I, fig. 9.

Near the preceding species and closely allied to the Formosan *C. synnephes* Hendel, but distinguished by the unspotted face and the longer ovipositor of the female.

LUZON, Laguna Province, Los Baños (*Baker*), Paete (*McGregor*). PANAY, Antique Province, Batbatan Island (*McGregor*). MINDANAO, Davao (*Baker*). Type in Professor Baker's collection.

*Male and female.*—Length of body, 6 to 6.5 millimeters; of ovipositor, 1.8 to 2; of wing, 6 to 6.5. Occiput rather convex and shining, yellowish, with a broad reddish brown or blackish patch on each side in the middle; sometimes blackish, with a broad yellow border. Frons of usual shape, less than twice as long as broad; dull yellowish, shining on sides and at vertex; ocellar dot black, lateral and central darkish spots less developed or even wanting. Lunula reddish brown. Antennæ as long as face, first joint short and third narrow and linear, very shortly pubescent; yellowish, with third joint broadly infuscated above and at end. Face shining yellowish and quite unspotted; cheeks linear; jowls as broad as third antennal joint; subocular spot small, brown. Palpi broad, yellowish; proboscis dirty brown. All the bristles black; usually two terminal pairs of lower orbital bristles, very close together and the anterior one much smaller and sometimes wanting.

Back of mesonotum black, punctulate, with pale yellowish pubescence; in the middle two less-distinct longitudinal stripes of grayish dust; beyond the suture three broad yellow longitudinal

[13] Bull. Ent. Research 7 (1916) 110.
[14] Tijdschr. voor Ent. 57 (1914) 191.

stripes, the middle one even broader than supra-alar ones, and all abbreviated before scutellum; humeral and notopleural calli yellow; yellow supra-alar stripes continued with a small yellow spot in front of suture. Pleura black, with reddish sutures and reddish propleural region; on mesopleuron a broad yellow patch continued below with a rather large spot on upper part of sternopleuron; a double yellow hypopleural spot. Mesophragma and postscutellum entirely black. Scutellum yellow, punctulate and whitish dusted, with a very narrow, black basal stripe; two pairs of bristles, the basal pair a little weaker than the apical. All the bristles black; middle scapular long and strong; one anterior supra-alar; pteropleural weaker than mesopleural. Halteres and squamulæ whitish.

Abdomen rounded and convex, restricted at base, with normal segmentation, punctulate and pubescent like back of mesonotum. First and second segments together more yellowish, chiefly on posterior half of second; black at base and on sides, the black base of second forming a black transverse middle band, not reaching sides; long whitish hairs near the base. Third segment reddish; a broad and complete black basal band, broadened on sides; fourth and fifth segments reddish, with a broad black patch on each side; last three segments with a black longitudinal middle stripe, united at base with the black band of third segment, and at end abbreviated a little before reaching hind border of fifth segment. Third segment of male with long black cilia; oval patches of fifth segment in both sexes more opaque and more dusted than the surrounding parts; ovipositor as long as last two abdominal segments together, rather swollen, reddish, more or less infuscated above at base and at end. Venter reddish, with black basal and terminal sternites. Coxæ more or less brownish; femora yellowish, broadly infuscated at end, those of front pair almost entirely infuscated; four anterior tibiæ blackish, two posterior ones even quite black in the female; in the male all tibiæ more lightly colored with darkened end; tarsi whitish at base.

Wings (Plate I, fig. 9) proportionally broad and long, shining and iridescent; nervation normal, with second vein straight, third a little curved downward at end; small cross vein placed a little beyond middle of discoidal cell; last portion of fourth vein curved at base. Supernumerary lobe of male very prominent and exaggerated. Pattern very much like that of *C. synnephes;* costal cells hyaline; costal border narrow, not extending below beyond second vein or only a little so, and not dilated at

end, ending near the middle of exterior border of first posterior cell. First basal cell infuscated above the second; hind cross vein margined with fuscous, fuscous border narrow above, broadened below, and dilated along hind border of wing into third posterior cell, to reach sometimes (chiefly in the male) the anal stripe. The last is very broad and long, being dilated at end in the male and reaching hind border of wing.

16. Chaetodacus tetrachaetus sp. nov. Plate I, fig. 10.

Related to the preceding species and likewise distinguished from *C. caudatus* by the smaller size, the black mesonotum, and the distal end of the costal border of the wings not being broadened; but it is distinguished from *C. mundus* and from *C. synnephes* by the brown anal stripe of the wings being quite wanting.

PANAY, Antique Province, Batbatan Island (*McGregor*). Type in my collection.

*Male.*—Length of body, 6.5 to 7 millimeters; of wing, 6.5 to 7. Head and its appendages as in *C. mundus;* frons without lateral brown spots, but with a distinct and convex middle dark spot, the latter clothed with dense and rather long pubescence; two shining black oval spots on face near end of antennal grooves. Cephalic bristles black; only two pairs of lower orbitals.

Back of mesonotum as in *C. mundus*, but yellow supra-alar stripe prolonged in front of suture to reach humeral calli, as in *C. continuus;* it is moreover reddish in front between humeral callosities, and on sides at outer border of the yellow supra-alar stripe, pleura, mesophragma, and scutellum as in *C. mundus*, but propleural region, lower border of sternopleuron, and breast more broadly reddish; scutellum pellucid on its central part, the yellow sides thus forming a pair of yellow spots. Bristles, squamulæ, and halteres as in *C. mundus.*

Abdomen as in *C. mundus*, but black basal band of second segment extending to sides, being there united with the black lateral border; middle black longitudinal stripe broader and extending to hind border of last segment; lateral black spots of fourth and fifth segments narrower and forming an equal black border; black cilia of third segment more numerous. Femora entirely yellowish and quite unspotted; front and middle tibiæ more or less infuscated; hind tibiæ black and strongly tuberculate before the end; pretarsi whitish.

Wings (Plate I, fig. 10) as in *C. mundus*, but with the super-

numerary lobe less developed; costal brown border narrow and short, not at all dilated at end, and ending only a little beyond end of third longitudinal vein; first basal cell infuscated above second; hind cross vein not infuscated; no brown anal stripe, the anal cell and its prolongation being quite hyaline; only a broad grayish spot around the end of the point of anal cell into third posterior and axillary cells.

*Note.*—From *C. continuus* the present species is distinguished by the four scutellar bristles, and by the much narrower and much shorter end of the costal brown border of the wings; in *C. continuus* the back of mesonotum is, moreover, reddish in the middle even beyond the suture to the scutellum, while the breast is blacker.

17. **Chaetodacus scutellinus** Bezzi.

*Chaetodacus scutellinus* BEZZI, Bull. Ent. Research 7 (1916) 113, pl. 2, fig. 11.

A small species, evidently allied to the preceding two, but at once distinguished by the black apical spot on the scutellum.

LUZON, Laguna Province, Mount Maquiling (*Baker*). PALAWAN, Puerto Princesa (*Baker*). Types in Professor Baker's collection.

In the above-cited paper I gave only a summary indication of the present species, of which a complete description follows:

*Male and female.*—Length of body, 5 to 5.5 millimeters; of ovipositor, 1; of wing, 5 to 5.5. Occiput dark reddish brown in the middle, with a broad and complete yellow border. Frons narrow, about twice as long as broad, opaque, yellowish, a little shining on sides and at vertex, with a small black ocellar dot, a narrow fuscous crossband at vertex, some small, less-distinct, darkish dots at sides, and a small, dark, subquadrate spot in the middle; lunula reddish brown, and above it a darkish crossband in the male. Antennæ yellowish, as long as face, with short first joint; third joint narrow, a little infuscated above and at end. Face concave, shining yellowish, with a small black spot at end of each antennal groove, and moreover with a less-marked dark spot in the middle, above mouth border. Cheeks linear; jowls a little narrower than third antennal joint, with a dark subocular spot. Palpi yellowish; proboscis blackish. Cephalic bristles black; only two pairs of lower orbitals.

Back of mesonotum black, being narrowly reddish only above wings at outer side of yellow supra-alar stripe; punctulate and rather opaque, with a short pale yellowish pubescence; the two broad, grayish, longitudinal stripes distinct in front of suture

alone. Yellow markings as follows: Humeri entirely; notopleural calli; three equally broad longitudinal stripes beyond suture, all abbreviated behind; two supra-alar stripes, one on each side, not at all prolonged in front of suture. Pleura black and rather shining, narrowly reddish in front; a moderately broad yellow stripe on mesopleuron, continued below with a small yellow spot on upper part of sternopleuron; two broad, contiguous, yellow hypopleural spots. Mesophragma entirely black. Scutellum yellow, with a very narrow, black, basal stripe; four bristles, between the apical pair a well-defined subquadrate black spot. Thoracic bristles quite black; middle scapular and pteropleural weak; one anterior supra-alar; prescutellar rather strong. Squamulæ and halteres whitish.

Abdomen oval, not much convex, less restricted at base, with distinct segmentation, punctulate and pubescent like back of mesonotum; first and second segments more yellowish, with black base and black borders, the black basal border of second extending to sides; third, fourth, and fifth segments of a more reddish color, third with a broad and complete black basal band, which is not broadened on sides; middle longitudinal black stripe of last three segments narrow but complete and equal, extending to hind border of fifth segment; last two segments with broad black spots on sides; fifth segment with less distinct oval patches; sixth segment more distinct than usual, being visible from above, and yellowish with a black middle stripe. Venter yellowish, with black sternites, chiefly the last ones in the male; third abdominal segment of male with black cilia; male genitalia reddish brown; ovipositor reddish, rather swollen at base, as long as last three abdominal segments together. Legs with dark brown coxæ; femora yellowish, with a blackish patch before the end; tibiæ yellowish or reddish, but those of the hind pair of legs blackish and in the male distinctly tuberculate before the end; tarsi reddish with whitish base.

Wings (Plate II, fig. 1) proportionally narrow and long, with distinct but not much developed supernumerary lobe in male; last portions of third and fourth veins straight and parallel; small cross vein placed a little beyond middle of discoidal cell. Costal border narrow, not surpassing second longitudinal vein toward the middle, only a little broader at end, but not dilated, and ending obliquely near the middle of exterior border of first posterior cell; costal cells hyaline; stigma blackish; first basal cell infuscated above the second; hind cross vein not infuscated Anal stripe rather broad and dark, but not dilated at end; shorter and paler in the female.

18. Chaetodacus pubescens sp. nov. Plate II, fig. 2.

*Chaetodacus scutellatus* BEZZI (not of Hendel), Bull. Ent. Research 7 (1916) 114.

Much larger and more pubescent than the preceding species, and moreover distinct on account of the different pattern of thorax, legs, and wings; it is closely allied to true *C. scutellatus* Hendel, from Formosa, differing only in the broader frons and in minor details of thoracic and abdominal markings.

LUZON, Laguna Province, Los Baños and Mount Maquiling (*Baker*). Type in Professor Baker's collection.

*Male*.—Length of body, 8.5 millimeters; of wing, 8. It seems to differ from Hendel's description of *C. scutellatus* in the following points: Frons broader, being not twice as long as broad. On back of mesonotum the yellow humeral calli surrounded with reddish, not with black; middle yellow longitudinal stripe broader than lateral ones. Abdomen with black basal bands only on second and third segments; fourth and fifth segments with only a broad black spot on each side. Opaque oval patches of fifth segment distinct; fifth segment, moreover, longer than usual, being only a little shorter than the two preceding segments together. Legs entirely reddish yellow and quite unspotted, only the hind tibiæ being brownish. Apical fuscous spot of costal border broader, extending below to middle of first posterior cell (Plate II, fig. 2); no distinct infuscation at lower end of hind cross vein or only a very much less-developed one. Pubescence of body longer than in any of the allied forms.

*Note*.—In consequence of my mistake in regard to the Philippine species here described as *C. pubescens*, the Japanese (and Chinese) species, to which Miyake [15] has recently given the name of *Dacus bezzii*, is probably the same as the Formosan *C. scutellatus* Hendel; at least I cannot distinguish them from descriptions and figures.

## III. Genus MELLESIS Bezzi, 1916

All the species here comprised in the present genus are typical in having a well-developed basal stalk of the abdomen (except *M. subsessilis*), an elongated first antennal joint, a mesonotum with interrupted suture and with no prescutellar bristles, and a scutellum with only the apical pair of bristles. They all have nonspinose femora, distinct lower orbital bristles (except *M. bioculata*), and well-developed anterior supra-alar bristles. To

[15] Bull. Imp. Central Agr. Exp. Sta. Japan 2 (1919) 146, pl. 2, fig. 2.

the characters of the genus may be added: Face very short in the middle, much shorter than the antennal grooves, which are sometimes twice as long as it. Lunula broad. Scutellum short and transverse. Wings short, distinctly shorter than body. The swollen ovipositor, on account of the abdominal club being very convex above and very concave beneath, is placed very deeply below the rounded hind border of the last abdominal segment.

*Chaetodacus bakeri*, of which I am not sure about the presence of the prescutellar bristles, and which, for *Chaetodacus*, has an unusually broad frons, is perhaps a member of the present genus; but in this case it may be distinguished from all the others by its first antennal joint being not elongated. The face, however, is long and shaped as in *Chaetodacus*.

The species of *Mellesis* seem to be rarer in the Islands than those of the preceding genus; at least I have received only few and scattered specimens of them. They can be distinguished with the aid of the following table; two of them (*M. pedunculata* and *M. nummularia*) are already named, but not described by me in another paper. [16]

$a^1$. Abdominal stalk less developed, short, broad, and depressed; fourth and fifth abdominal segments entirely reddish at sides. **M. subsessilis** sp. nov.

$a^2$. Abdominal stalk very distinct, long, thin, and cylindrical; last abdominal segments with black spots at sides.

- $b^1$. Frons very broad, with less-developed lower orbital bristles; a single yellow hypopleural spot; oval patches of fifth abdominal segment black; wings with narrow and elongate second basal cell, with no distinct anal stripe, and with costal border equally broad to the end ..... **M. bioculata** sp. nov.
- $b^2$. Frons narrower and with well-developed orbital; hypopleural spot double; oval patches not black; wings with short and broad second basal cell.
  - $c^1$. Face with a black transverse band just above mouth border; mesonotum with no yellow postsutural middle stripe; costal border of wings narrow, not extending beyond third vein or only a little so near the end; no brown anal stripe on wings. **M. pedunculata** Bezzi.
  - $c^2$. Face with two black spots; mesonotum with yellow middle stripe; costal border dilated at end into a very broad rounded spot, which is extended below into second posterior cell; anal stripe well developed ..... **M. nummularia** Bezzi.

19. **Mellesis subsessilis** sp. nov. Plate II, fig. 3.

A robust species of proportionally greater size, very distinct

[16] Bull. Ent. Research 7 (1916) 115.

on account of its less-stalked abdomen, which, moreover, lacks the lateral black spots.

PANAY, Antique Province, Culasi (*McGregor*), June, 1918. Type, a single female specimen, in my collection.

*Female*.—Length of body, more than 9 millimeters; of ovipositor, 1.5; of wing, 8. Occiput of a shining, pale reddish color, with a broad, pale-yellowish border. Frons parallel-sided, one and one-half times as long as broad, opaque, with shining vertical plates; dirty reddish with yellow sides, a broad, rounded, darkish spot, clothed with erect pubescence on its front half; dark orbital spots indistinct; lunula very broad, shining reddish yellow. Face short and broad, flat in the middle but prominent at mouth border, shining yellow, with a broad black spot on inner apical side of each antennal groove; cheeks rather broad; jowls broader than breadth of third antennal joint. Antennæ with third joint wanting in the type, but to judge from the two basal joints they must be very long, much longer than face; first joint as long as elongate second joint, both yellowish in color. Palpi yellowish; proboscis dirty reddish. Cephalic bristles black, even the rather strong genal one; two pairs of well-developed lower orbitals; postvertical short and yellowish, hairlike.

Thorax broad and robust, rather convex above; on back of mesonotum punctate and clothed with proportionally long, pale-yellowish pubescence; opaque black on middle, reddish in front, on sides, and before scutellum. Yellow markings as follows: Entire humeral calli; notopleural calli; and a broad transverse stripe in front of the suture, as broadly interrupted in the middle as thoracic suture. Pleura punctate and less shining, with whitish pubescence; reddish, broadly black in the middle, with the following yellow markings: A mesopleural stripe, continued with a not much larger yellow spot on upper border of sternopleuron; a double hypopleural spot. Mesophragma entirely black like postscutellum, gray dusted, hardly reddish brown in the middle. Scutellum proportionally small, punctate and pubescent like back of mesonotum, yellow, with a narrow brownish basal stripe; bearing only the apical pair of bristles, the latter black. Thoracic bristles black, scapular bristles very strong and long, even those of middle pair; one anterior supra-alar; no prescutellar; pteropleural weaker than mesopleural. Squamulæ and halteres whitish.

Abdomen rather elongate and convex; not properly stalked at base, first segment being not much restricted and not cylindrical;

prominent basal tubercles of first segment very well developed; punctulate and pubescent like back of mesonotum, but the first two segments clothed on sides with long, erect, whitish hairs. First segment entirely reddish, with less-distinct, darkish, longitudinal middle stripe; second segment reddish at base, yellowish on more than its apical half, with less-distinct middle stripe, and with no black spots at sides; third, fourth, and fifth segments entirely reddish, with no black spots on sides, with only a narrow and complete, black longitudinal stripe in the middle; venter very concave; reddish, with brown apical sternites. Segmentation distinct; sixth segment not visible. Ovipositor reddish, very much swollen at base. Legs entirely reddish, with pale pubescence; tibiæ paler, base of tarsi whitish; middle tibiæ with a strong black spur.

Wings (Plate II, fig. 3) shorter than body, shining and iridescent; veins reddish; second longitudinal vein straight; last portions of third and the fourth parallel, the latter less curved at base; small cross vein placed beyond middle of discoidal cell. The pattern consists of a yellowish and broad, complete costal border, comprising even costal cells and extending below to third vein; in first posterior cell this border extends below third vein to reach middle of cell and is more intensively dark; this darker, but less-sharply defined, apical spot continued below with a darkish shade, passing over fourth vein into upper part of second posterior cell. Stigma not darker; first basal cell darkened above second. Yellowish anal stripe broad, but not extending to hind border of wing. Second basal cell rather broad.

20. Mellesis bioculata sp. nov. Plate II, fig. 4.

Very distinct from all the other species on account of the single hypopleural spot and the peculiar wing pattern.

LUZON, Laguna Province, Mount Maquiling (*Baker*). Type in Professor Baker's collection.

*Male.*—Length of body, 10 millimeters; of wing, 8.5. Head as in the preceding species, but frons distinctly shorter and broader, being about as long as broad; of the antennæ there is only the first joint, which is elongate and yellowish; black facial spots much smaller and rounded; cephalic bristles black, but it seems that the lower orbitals are very much less developed, only the first pair being distinguishable.

Mesonotum distinctly narrower; entirely reddish on the back, with three very narrow, blackish longitudinal stripes and two

blackish spots in front of scutellum; humeri yellow, but with interior hind border reddish; yellow sutural stripe narrower. Pleura entirely reddish, only a little darkened around the yellow markings; yellow mesopleural stripe narrower; only the hypopleural yellow spot present, that on sides of mesophragma being indistinct or only indicated by a more-yellowish inner border in contact with the above-named spot; mesophragma entirely reddish and unspotted. Bristles as in the preceding, with anterior supra-alar bristle well developed. Scutellum small and short, much broader than long, yellow with a narrow brownish basal stripe. Halteres and squamulæ whitish.

Abdomen with long, narrow, and cylindrical stalk; first and second segments dark brownish, with a narrow yellow hind border; third segment uniformly blackish brown; fourth segment blackish brown, with a rectangular, transverse, yellowish spot in middle at hind border; fifth segment yellowish, with broad blackish patches on sides, and with the two oval patches likewise black, hind border of segment entirely pale yellowish. Venter with blackish terminal sternites. Long, whitish, erect pubescence near base of abdomen. Legs reddish, femora broadly blackish; base of tarsi not whitish; middle femora with a pale yellowish base.

Wings (Plate II, fig. 4) as in the preceding, but with second basal cell much longer and narrower. The pattern consists of an equal, dark, costal border, extending from base to tip of wing, surpassing a little the third longitudinal vein below; no spotlike dilatation at end; anal stripe not distinct or else indicated only by a yellowish shading. Prolongation of anal cell very long, extending about to hind border of wing. No supernumerary lobe at end of sixth vein.

*Note.*—The present species belongs in the group with the Indian *M. crabroniformis* Bezzi, and the Burman *M. destillatoria* Bezzi; it has likewise no developed lower orbital bristles, a single yellow hypopleural spot, a narrow and elongate second basal cell, a similar wing pattern with a broad and equal costal border, and with no developed anal stripe. It is, however, distinguished from both by the black oval patches of the fifth abdominal segment and by the differently colored legs. The species *M. aequalis* Coquillett, *M. longicornis* Wiedemann (= *vespoides* Doleschall), and *M. eonopoides* de Meijere, evidently belong to the same group, but the last two are said to have spinose front femora.

21. Mellesis pedunculata Bezzi. Plate II, fig. 5.

*Mellesis pedunculata* BEZZI, Bull. Ent. Research 7 (1916) 115.

A small species with a well-stalked abdomen, very distinct on account of its banded face and its simple wing pattern.

LUZON, Laguna Province, Mount Maquiling (*Baker*). Mindanao, Davao (*Baker*). Type in Professor Baker's collection.

*Male.*—Length of body, 7.5 millimeters; of wing, 6; of the whole antenna, about 2. Occiput black in the middle, with a reddish spot above from neck to vertex, and with a yellow border, the latter a little broadened below. Frons proportionately narrow, less than twice as long as broad; reddish at base with yellow vertical plates, with yellow borders, and moreover rather yellowish in front; at vertex a black crossband including the black ocellar dot; a dark spot toward the middle shaped as a broad transverse band. Lunula broad, shining brownish. Face very short in the middle, with less prominent mouth border; shining yellowish, with a shining black transverse band just above mouth border, rather dilated toward middle of antennal grooves; a small black spot just below root of antennæ. Cheeks not properly linear; jowls broader than third antennal joint, with a brown subocular spot. Antennæ very long, much longer than face; first joint very elongate, entirely reddish, nearly bare; second joint a little shorter than first, blackish at base, reddish at end, with dark hairs; third joint narrow and elongate, quite blackish; arista yellowish, about as long as the whole antenna. Palpi and proboscis dirty yellowish. Cephalic bristles black; two pairs of well-developed lower orbitals; genal bristle well developed; postverticals not distinct or hairlike.

Mesonotum broad and less convex, with interrupted suture; punctate, opaque, clothed with a short yellowish pubescence; back reddish, with two black, longitudinal, middle stripes, prolonged beyond suture but not reaching scutellum, and with two broad black patches, one on each side, including the interrupted, yellow, transverse sutural stripe; humeral callosities entirely yellow. Pleura black in the middle, reddish on sides and below, punctate like the back but a little more shining; yellow mesopleural stripe moderately broad, continued below with a yellow spot on upper border of sternopleuron; hypopleural spot double. Mesophragma black, with a reddish vertical stripe along the middle. Scutellum twice as broad as long, yellow, with a nar-

row reddish-brown basal stripe; with two black bristles at end. Thoracic bristles black; middle scapular as strong as lateral ones; one anterior supra-alar; pteropleural a little weaker than sternopleural. Squamulæ dirty whitish; halteres whitish.

Abdomen with a thin, cylindrical basal stalk and with an oval terminal club; punctate and pubescent like back of mesonotum, but long and erect whitish hairs at base on sides; segmentation distinct; third segment with long black cilia. First and second segments black with yellowish hind border, that of second being broader and not extending to sides; third segment entirely black; fourth and fifth segments long, the latter longer than the former, black, with a broad reddish yellow middle patch, which has on the middle a narrow, black longitudinal stripe, ending before hind border of last segment. Oval patches of fifth segment less distinct, shining but not differently colored. Venter very concave, with yellowish membrane and with black sternites, basal one clothed with long whitish hairs; genitalia reddish. Coxæ reddish brown; femora black in the middle, yellowish at base, reddish at end; tibiæ reddish, more or less darkened, the posterior ones being more broadly blackish; tarsi reddish, with pale base; spur of middle tibiæ long and black.

Wings (Plate II, fig. 5) proportionally short, shining and iridescent. Veins black, second straight, third less curved downward at end and parallel with the last portion of fourth, which is less curved at base; small cross vein a little beyond middle of discoidal cell; second basal cell broad, but about twice as long as broad; prolongation of anal cell very long; no supernumerary lobe. Pattern very simple and less developed, consisting only of a narrow, dark, costal border, in the middle not extending beyond second longitudinal vein, while at end it is a little dilated below third vein but without being spotlike. First basal cell infuscated above second; hind cross vein not infuscated; anal stripe quite wanting, only a grayish shade being present at end of the point of anal cell, into the terminal outer angle of the axillary cell. Costal cells a little infuscated; stigma darker.

*Note.*—The description of the Javanese *M. conopoides* de Meijere is very much like that of the present species, which, however, is different in having well-developed lower orbital bristles and in having nonspinose front femora.

22. **Mellesis nummularia** Bezzi. Plate II, fig. 6.

*Mellesis nummularia* BEZZI, Bull. Ent. Research 7 (1916) 115.

Allied to the preceding species, but distinct by the paler coloration of the body and of the legs, as well as by the richer wing pattern, which has a broad, rounded, apical, dark brown patch.

LUZON, Laguna Province, Los Baños, Mount Maquiling and Mount Banahao (*Baker*). Types in Professor Baker's collection.

*Male and female.*—Length of body, 8 to 8.5 millimeters; of wing, 7 to 7.5; of antenna, more than 2; of ovipositor, 1.5. Head and its appendages as in the preceding species; but occiput reddish, with a narrow yellow border, frons less distinctly yellow on sides, with a black ocellar dot, a reddish brown vertical stripe, and the middle transverse spot less developed; face without black spot just below root of antennæ, and with two broad rounded black spots, one on each side toward middle of antennal grooves; antennæ paler, third joint being only in part infuscated; two pairs of lower orbital bristles thinner, but always well developed.

Mesonotum as in the preceding and with the same yellow markings; but prevalently reddish on back, the black pattern being reduced to a narrow, middle, longitudinal stripe, ending at suture, and to two small patches, one on each side, near the yellow sutural stripe; characteristic for the present species is a short yellow middle stripe, which begins acutely just beyond suture and ends obtusely midway between suture and scutellum. Pleura entirely reddish, with only a small black patch on mesopleuron in front of yellow mesopleural stripe. Mesophragma reddish, with blackish sides; postscutellum reddish; scutellum as in the preceding species. Chætotaxy the same and bristles likewise black.

Abdomen as in the preceding, but with basal stalk a little broader; second segment more broadly yellowish at hind border, and in the middle a short, dark, longitudinal stripe not reaching hind border; third segment yellowish in the middle behind, the yellow being thus united with the yellowish patches of the last two segments, and the middle longitudinal black stripe beginning with it. Cilia of third segment longer; ovipositor conical, dark reddish. Four anterior femora more or less blackened, the posterior ones being quite yellowish and unspotted.

Wings (Plate II, fig. 6) in shape and venation as in the preceding species, but with reddish veins. Costal border less darkened, more yellowish, and extended in the middle to third longitudinal vein; at apex of wing a broad, rounded, dark spot, which extends below beyond fourth vein, entering with its lower border into second posterior cell; end of first posterior cell narrowly subhyaline, the apical spot being thus rather separated from wing border; inwardly the apical spot extends to a little before upper end of hind cross vein. Anal stripe well developed, but not reaching hind border of wing and not dilated at end. First basal cell infuscated above second; hind cross vein not bordered with fuscous.

### IV. Genus MONACROSTICHUS Bezzi, 1913

The long, convex, and bituberculate face, the lack of lower orbital bristles, the continuous transverse suture of mesonotum, the unpaired acrostichal bristle, the spinose front femora, the narrow second basal cell, and the restricted base of the discoidal cell are the main features of this very distinct genus. To these may be added that the first posterior cell is narrowed at end, and that the sixth longitudinal vein is not extended to the hind border of the wing. The anterior supra-alar bristle is present, while the middle scapular bristles are wanting.

23. **Monacrostichus citricola** Bezzi. Plate II, fig. 7.

*Monacrostichus citricola* BEZZI, Philip. Journ. Sci. § D 8 (1913) 323.

Distinguished from all the preceding species of the genus *Mellesis* by the peculiarly patterned face with entirely black antennal grooves; by the yellow supra-alar stripes on the sides of mesonotum, even a short posthumeral stripe being present; by the complete black crossbands at base of fourth and fifth abdominal segments; by the nonciliated third abdominal segment of the male; by the flattened ovipositor of the female; and by the very simple wing pattern (Plate II, fig. 7). The dark transverse band of the face in the present species is not placed just above the mouth border as in *M. conopoides* or in *M. pedunculata;* but it is narrow and placed toward the middle, just below the upper facial tubercle; it is saddle-shaped, and from its lower angle branches a short, vertical, dark stripe, which runs to the upper mouth border.

LUZON, Laguna Province, Los Baños (*Baker*), reared from *Citrus* fruits. I have seen only the typical specimens.

# ILLUSTRATIONS

[Drawings by M. Bezzi.]

PLATE I

FIG. 1. *Chaetodacus atrichus* sp. nov., wing of female.
2. *Chaetodacus ablepharus* sp. nov., wing of male.
3. *Chaetodacus ferrugineus occipitalis* var. nov., wing of male.
4. *Chaetodacus ferrugineus pedestris* Bezzi, wing of male.
5. *Chaetodacus ferrugineus limbiferus* var. nov., wing of male.
6. *Chaetodacus continuus* sp. nov., wing of female.
7. *Chaetodacus megregori* sp. nov., wing of male.
8. *Chaetodacus bakeri* sp. nov., wing of male.
9. *Chaetodacus mundus* sp. nov., wing of male.
10. *Chaetodacus tetrachaetus* sp. nov., wing of male.

PLATE II

FIG. 1. *Chaetodacus scutellinus* Bezzi, wing of male.
2. *Chaetodacus pubescens* sp. nov., wing of male.
3. *Mellesis subsessilis* sp. nov., wing of female.
4. *Mellesis bioculata* sp. nov., wing of male.
5. *Mellesis pedunculata* Bezzi, wing of male.
6. *Mellesis nummularia* Bezzi, wing of male.
7. *Monacrostichus citricola* Bezzi, wing of male.

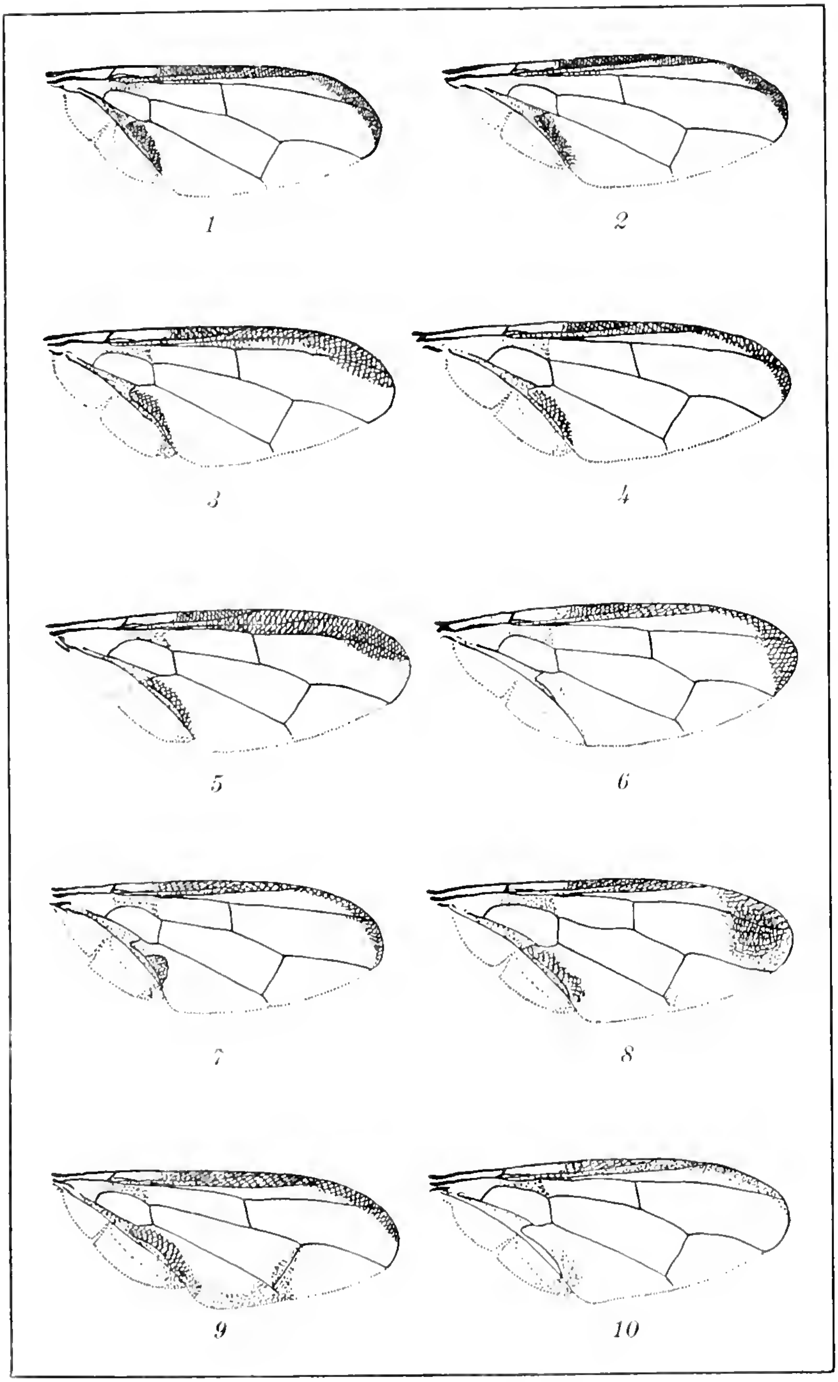



PLATE I. PHILIPPINE FRUIT FLIES.

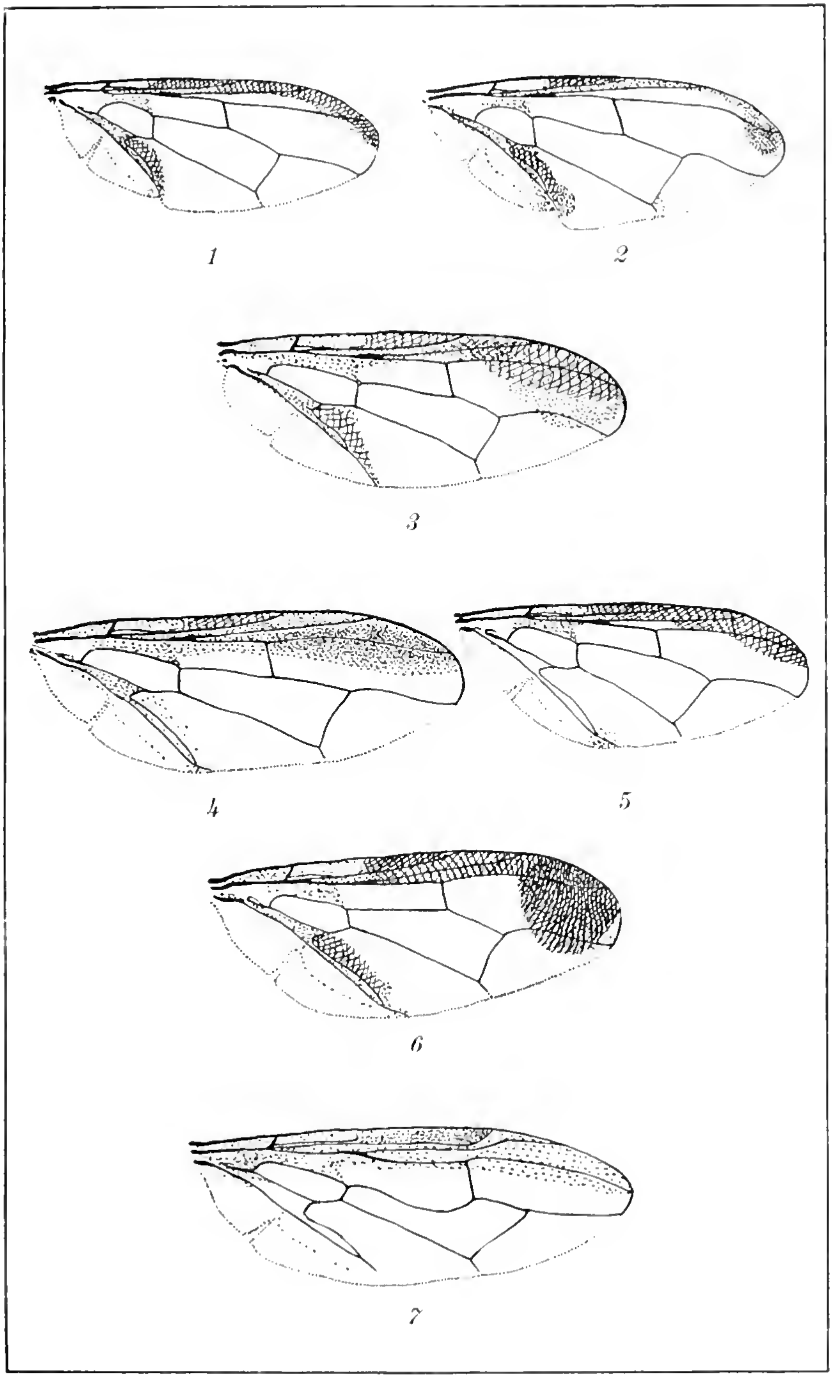



PLATE II. PHILIPPINE FRUIT FLIES.

# MELASIDÆ NOUVEAUX (COLÉOPTÈRES) RÉCOLTÈS PAR C. F. BAKER

Par Ed. Fleutiaux

*Nogent-sur-Marne, France*

Depuis la publication d'un premier mémoire sur les Melasidæ recueillis aux Iles Philippines par M. Baker,[1] j'ai recu de lui plusieurs autres envois contenant des espèces de la région indo-malaise dont un certain nombre sont nouvelles. Il donne ci-après les descriptions de quelques unes d'entre elles.

**Subprotelater guttatus** sp. nov.

Allongé, parallèle, peu convexe, noir mat, pubescence jaune à peine apparente, élytres ornés chacun de quatre taches blanchâtres. Tête convexe á ponctuation large et ombiliquée; épistome brunâtre, largement impressionné. Antennes noires, n'atteignant pas la base du prothorax, ferrugineuses á la base. Pronotum plus long que large, à peine rétréci en avant, brusquement déprimé à la base; ponctuation large et ombiliquée; angles postérieurs aigus et carénés. Ecusson perpendiculaire. Élytres parallèles, arrondis au sommet, rugueux, fortement ponctués-striés, ornés de quatre tâches blanchâtres à peu près semblables: une à la base en dedans de l'angle huméral; une autre au premier tiers, sur les 3^e^ et 4^e^ interstriés; une troisiéme un peu plus grande, arrondú avant l'extrémité près du bord latéral; la quatrième au quart antérieur du bord latéral sur les trois dernièrs interstriés. Dessous le même couleur. Propectus à ponctuation grosse assez serrée. Métasternum à ponctuation moins forte. Episternes parallèles de la même largeur que les épipleures. Hanches postérieures non rétrécies en dehors; bord externe beaucoup plus large que les episternes; bord inférieur sinué. Ponctuation de l'abdomen semblable à celle du métasternum. Pattes ferrugineuses, fémurs plus au moins noirâtres.

Longueur, 3.5 millimètres.

Singapore.

Plus court que *P. bakeri* Fleutiaux. Élytres sans bandes ranges obliques en arrière de l'écusson, ni tache linéaire sub-

[1] Philip. Journ. Sci. § D 11 (1916) 387.

suturale près du bout; la tache ronde subapicale plus en arriére.

**Dromaeolus cylindricus** sp. nov.

Allongé, cylindrique, noir, brillant sur la partie postérieure des élytres, pubescence jaune sur la moitié antérieure, obscure sur la moitié postérieure. Tête convexe, assez fortement et densément ponctuée; épistome rétréci à la base où il est deux fois plus étroit que l'espace compris entre le fond de son échancrure et l'oeil. Antennes noirâtres, subcomprimiés, dépassant à peine la base du pronotum; 4^e et 5^e articles égaux, un peu plus longs que larges. Pronotum plus long que large, parallèle, arrondi en avant, convexe, aplati et sillonné au milieu en arrière, assez fortement rugueux. Élytres parallèles en avant, graduellement rétrécis en arrière, aplatis et biimpressionnés à la base, convexes à l'extrémité, rugueux sur la tiers antérieur, très finement ponctué au delà, très légèrement striés. Dessous de même couleur, pubescence semblable sur toute la surface; ponctuation assez forte. Episternes suparallèles, un peu plus étroits que les épipleures. Hanches postérieures dilatées en dedans, plus larges en dehors que les épisternes. Dernier segment abdominal en pointe obtuse. Pattes noirâtres, tarses brunâtres; tibias et tarses antérieurs ferrugineux.

Longueur, 6 millimètres.

BORNÉO, Sandakan.

Moins allongé que *D. semigriseus* Bonvouloir. Partie antérieure du corps moins densément rugueuse; front sans caréne; pronotum moins long, moins convexe en arrière; élytres distinctement biimpressionnés à la base.

**Dromaeolus bipartitus** sp. nov.

Allongé, subcylindrique, noir peu brillant, pubescence grise sur la moitié antérieure, brune sur la moitié postérieure. Tête convexe, finement et densément ponctuée; épistome aussi large à la base que l'espace compris entre le fond de son échancrure basale et l'oeil. Antennes noires. Pronotum un peu plus long que large, parallèle en arrière, arrondi dans la moitié antérieure, convexe, fortement déprimé à la base, sillonné au milieu sur les deux tiers de sa longueur; ponctuation assez forte, serrée et subrugueuse sur la milieu, plus légère en avant qu'en arrière, presque effacée le long de la base. Élytres subparallèles en avant, faiblement et graduellement attenués au delà de la moitié, déhiscents au sommet, terminés en pointe légèrement striés;

ponctuation fine, très espacée surtout en arrière. Dessous noir peu brillant, pubescence grise peu apparente. Episternes parallèles, plus étroits que les épipleures. Hanches postérieures très élargées et anguleuses en dedans, de la même largueur en dehors que les épisternes. Dernier segment abdominal atténué en arrière, arrondi au sommet. Patte noires, tarses antérieurs et derniers articles des autres jaunâtres.

Longueur, 6.5 millimètres.

SINGAPORE.

Voisin de *D. cylindricus* Fleutiaux. Moins convexe et moïns cylindrique, moins fortement ponctué. Pronotum rétréci en avant à partir de la moitié. Élytres plus attenués en arrière, déhiscents à l'extrémité, plus brillants, à ponctuation plus légère écartée.

**Dromaeolus depressus** sp. nov.

Oblong, assez large, déprimé, noir brillant, pubescence formir de poils raides, jaune sur la tête, la pronotum et une partie des élytres, brune à l'extrémité. Tête assez convexe, très finement ponctuée, caréne interoculaire entiére; épistome très rétréci à la base, où il est plus étroit que l'espace compris entre lui et l'oeil. Antennes brun obscur, avec le sommet du premier article, la 2e et les derniers rougeatres; 2e à peu près de la longueur du 4e; 3e aussi long que les deux suivants réunis; 4e et 5e subégaux. Pronotum moins long que large arrondi en avant, peu convexe, faiblement déprimé à la base; ponctuation plus forte que sur la tête, peu serrée. Ecusson arrondi et ponctué. Élytres atténués en arrière, indistinctement striés, ponctuation plus serrée à la base, espacée au delà. Dessous de même couleur, ponctuation au peu plus forte en avant, plus serrée en arrière. Pattes ferrugineuses.

Longueur, 4.5 millimètres.

BORNÉO, Sandakan.

Voisin de *D. opacus* Bonvouloir; d'un forme générale plus courte et déprimée.

**Fornax dorsalis** sp. nov.

Elliptique, noir brillant, pubescence jaune apparente sur la base du pronotum et des élytres et formant une tache assez grande sur la suture au delà de la moitié. Tête à ponctuation fine, caréne interoculaire entiére; épistome très rétréci à la base. Antennes ferrugineuses; 2e article petit; 3e presque aussi long que les deux suivants réunis; 4e à peine plus long que la 2e.

Pronotum convexe en avant, déprimé en arrière, arrondi sur les côtés et rétréci en avant; ponctuation assez forte, peu serrée. Élytres graduellement rétrécis en arrière, arrondis au sommet, légèrement rugueux tout à fait à la base, finement et éparsément ponctuée, marqués seulement d'un seule strié suturale. Dessous brunâtre, pubescence jaune, ponctuation assez forte sur la propectus et la métasternum, fine sur l'abdomen. Pattes ferrugineuses.

Longueur, 3.5 millimètres.

Bornéo, Sandakan.

Même forme que *F. scutellaris* Fleutiaux. Aspect plus brillant, pubescence jaune moins étendue sur la pronotum et formant une tache sur la suture des élytres, ponctuation moins marquée sur la pronotum, base des élytres moins rugueuse.

Fornax umbilicatus sp. nov.

Fusiforme, convexe, brun noirâtre peu brillant, pubescence jaune sur la moitié antérieure, brune en arrière. Tête convexe, densément et assez fortement ponctuée, carénée au milieu; épistome rétréci à la base où il est plus étroit que l'espace compris entre le fond de son échancrure et l'oeil. Antennes ferrugineuses, cylindriques, dépassant à peine la base du prothorax; 2$^e$ article subégal au 4$^e$; 3$^e$ presque aussi long que les deux suivants réunis. Pronotum un peu plus long que large, parallèle en arrière, rétréci en avant au delà de la moitié, convexe, déprimé à la base, marqué sur les côtés d'une faible dépression et d'une ligne lisse sillonnée au milieu en arrière; ponctuation ocellée. Ecusson carré. Élytres graduellement rétrécies rugueuses à la base, éparsément ponctués en arrière, légèrement striés. Dessous de même couleur, pubescence plus fine, moins apparente; ponctuation forte et serrée sur la propectus et la metasternum, moins bien marquée sur l'abdomen. Prosternum sillonné transversalement près du bord antérieure sur une grande partie de sa largueur; saillie large et déprimée. Sillons antennaires nettement limités par leur fond lisse et brillant. Episternes étroits en avant, élargés en arrière. Hanches postérieures, triangulaires, larges, anguleuses, fortement rétrécies en dehors où elles sont un peu plus larges que la bord inférieur des épisternes. Dernier segment abdominal comprimé, râpeux au sommet, tronqué et ouvert, terminé au milieu par une dent. Pattes ferrugineux obscur; fémurs noirâtres; angles petits, minces, non dentés.

Longueur, 6.5 millimètres.

Bornéo, Sandakan.

Voisin de *F. fusiformis* Fleutiaux; plus grand, plus convexe, ponctuation en pronotum forte et ombiliquée. Egalement voisin de *F. tenuis* et de *F. subacuminatus* Bonvouloir par la forme du dernier segment abdominal.

**Fornax melanopterus** sp. nov.

Oblong, jaune rougeâtre, élytres noirs, pubescence jaune clair. Tête convexe, impressionnée en avant, ponctuation large et ombiliquée; caréne interoculaire interrompue au milieu; épistome rugueux, rétréci à la base où il est plus étroit que l'espace compris entre le fond de son échancrure et l'oeil. Antennes atteignant la moitié en corps, jaune obscur, premiers articles jaune clair, comprimées et dentées à partir du 3e article; 2e très petit; les suivant subégaux. Pronotum un peu plus long que large, parallèle, arrondi au sommet, convexe, déprimé en arrière, sillonné au milieu de la base; ponctuation ombiliquée. Ecusson presque carré, convexe, ponctué. Élytres sub-parallèles dans la premiere moitié et attenués en rond au delà, ponctués plus densément à la base, substriés. Dessous jaune rougeâtre. Pattes jaune pàle.

Longueur, 5 à 6 millimètres.

BORNÉO, Sandakan.

Jolie petite espéce dont la coloration rappelle *F. venustus* Bonvouloir. Taille beaucoup plus petite, antennes plus longues et dentées, ponctuation de la tête et en pronotum ombiliquée, celle des élytres plus grosse.

**Fornax diapodioides** sp. nov.

Allongé, convexe, brun, un peu rougeâtre sur les élytres surtout le long de la suture et plus clair au sommet, pubescence jaune, brune sur la disque des élytres en arrière et formant une tache oblongue n'atteignant pas l'extrémité et traversée par la pubesence jaune le long de la suture. Tête très convexe et densément ponctuée; épistome non caréné à la base où il est aussi large que l'espace compris entre le fond de son échancrure et l'oeil. Antennes ferrugineuses, filiformes, dépassant la base en prothorax; 2e article très petit; 3e un peu plus long que la 4e; suivant égaux. Pronotum plus long que large, parallèle en arrière, rétréci et arrondi en avant, convexe, marqué de deux faibles impressions en avant de la moitié, déprimé à la base de chaque côté du lobe médian; celui-ci saillant, tronqué en arrière; ponctuation assez forte, serrée et rugueuse, plus fine sur la partie déchiré de la base. Écusson assez grand, subquadrangulaire,

rugueux. Élytres convexes, légèrement déprimé de chaque côte de l'écusson, parallèles en avant, graduellement attenués à partir de la moitié, échancrés et bidentés au sommet, finement ponctués, légèrement rugueux à la base, substriés. Dessous d'un brun noirâtre, pubescence jaune. Abdomen convexe, dernier segment tronqué latéralement et terminé au milieu par une saillie arrondié. Pattes ferrugineuses; fémurs obscurées surtout les postérieurs; ongles petites et dentés.

Longueur, 6.5 millimètres.

BORNÉO, Sandakan.

Cette curieuse espéce rappelle par son aspect *Diapodius griseus* Bonvouloir. Sa pubescence bicolore affecte à peu près la même disposition.

**Dyscolocerus bakeri** sp. nov.

Oblong, convexe, ferrugineux plus brillant sur la pronotum, pubescence jaune peu abondante. Tête étroite, convexe, ponctuation assez large, peu profonde, légèrement rugueuse; épistome très étroit à la base où il est beaucoup moins large que l'espace compris entre lui et l'oeil. Antennes robustes, ferrugineuses à la base, obscures au sommet; 1^er^ article épais, aussi long que les trois suivants réunis; 2^e^ à 8^e^ plus étroits, courts, moniliformes, 3^e^ un plus long que les autres; 9^e^ environs aussi long que les 2^e^ a 8^e^ réunis; 10^e^ et 11^e^ de même longueur que la 9^e^, ces trois derniers plus épais que les précédents. Pronotum plus large que long, rétréci en avant, sinné sur les côtés, convexe, déprimé en arrière, brillant; ponctuation nette, peu serrée sur la disque, faiblement rugueuse latéralement. Élytres subparallèles, rétrécis en arrière à partir de la moitié, arrondis au sommet, convexes, légèrement déprimés à la base, densément ponctués, distinctement striés. Dessous de même couleur, ponctuation grasse et superficielle sur les propleures, plus fine et plus nette sur la prosternum; saillie courte, large. Métasternum à ponctuation fine et peu serrée. Episternes parallèles, plus étroits que les épipleures à la moitié en leur longueur. Hanches postérieures fortement et anguleusement élargies en dedans. Abdomen densément ponctué; dernier arceau largement arrondi. Pattes ferrugineux clair.

Longueur, 5 millimetrès.

BORNÉO, Sandakan.

Voisin de *D. subnitidus* Bonvouloir. Taille moindre, couleur plus claire, aspect plus brillant, dernier article des antennes aussi long que la précédent.

# SOME ABNORMALITIES OF THE VERTEBRAL ARTERY [1]

By Miguel Cañizares

*Of the Department of Anatomy, University of the Philippines, Manila*

ONE PLATE AND FIVE TEXT FIGURES

The considerable number of marked abnormalities of the vertebral artery met with in the department of anatomy in the course of our dissections there within the last two years, and their apparent practical importance and embryological significance, suggested the preparation of this report on the subject.

The observations were made on forty cadavers used in the dissecting rooms of the College of Medicine and Surgery, University of the Philippines. The cases were numbered from 1 to 40.

It is well known that the vertebral artery is one of the largest and most constant branches of the first portion of the subclavian, and that it has a different origin on each side. On the right side the artery arises from the subclavian about 2 centimeters from the origin of the latter from the innominate. On the left side, it arises from the most prominent part of the arch of the subclavian, close to the medial edge of the scalenus anterior muscle. On both sides it first ascends to the foramen transversarium of the sixth cervical vertebra and, having passed that foramen and the foramina of the succeeding cervical vertebræ as high as the epistropheus, it turns laterally and ascends to the foramen of the transverse process of the atlas. From that point it turns backward behind the articular process and, after piercing the posterior occipito-atlantoid membrane and the dura mater, enters the cranium through the foramen magnum. Both vertebral arteries terminate at the lower portion of the pons varolii by anastomosing to form the basilar artery.

While numerous observations on variations in the entrance of the vertebral artery to the foramen transversarium have been recorded, only a few reports on the abnormalities of its origin have been found by me.

Bean,(2) in one hundred twenty-nine cases studied, found only

[1] Read before the IV Asamblea Regional de Médicos y Farmacéuticos de Filipinas, February 5, 1918.

three instances of the abnormality in the origin of the left vertebral artery. In these the vessel arose directly from the arch of the aorta between the left common carotid and the left subclavian. He also found, in the same series, five cases of variation. In every case it arose from a common trunk, from part 1 of the subclavian in association with other arteries; three times with the inferior thyroid; once with the thyroid axis; and in one instance the right vertebral artery was double.

While it is a well-known fact that normally only three branches are given off from the aortic arch, yet there are cases where four or more vessels take origin from it. In the great majority of such instances, according to Thane,(8) the left vertebral artery originates from the arch between the left common carotid and the left subclavian, and only in rare instances between the right common carotid and the right subclavian.

In my series, I found two cases where the left vertebral artery originated from the aortic arch between the left common carotid and the left subclavian. In one instance (case 38) it ascended in front of the transverse processes of the lower cervical vertebræ until it reached the level of the third vertebra, there entering the foramen transversarium. In case 39, after following a similar vertical course, it entered the transverse foramen of the fifth cervical vertebra. The right vertebral artery in both cases was entirely normal (see Plate I, figs. 1 and 2).

Bean's observations, as well as mine, appear to confirm Thane's statement as to the more frequent aortic origin of the left vertebral artery between the left common carotid and the left subclavian.

Thirteen of the remaining cases in my series, while apparently normal in origin, showed abnormalities in the point of entrance to the foramen transversarium. To this number must be added the two cases described above which, besides having abnormal origin, also showed variations in the point of entrance to the transverse foramina.

The cases are classified into two groups; namely, cases showing the same bilateral point of entrance and cases in which the point of entrance differed on both sides.

There were six cases in group 1 (see Table I). In four the arteries entered the transverse foramen of the seventh cervical vertebra; in one, the foramen of the fifth; and in the other, that of the fourth cervical vertebra.

Nine cases were placed under group 2 (see Table II). Here there were five instances where the right artery entered the

normal, or sixth, cervical transverse foramen, and one where the left artery entered the sixth; the three remaining cases were abnormal on both sides.

On comparing figures it was found that my percentage of abnormalities of origin (5 per cent) was slightly higher than that of Bean (2.33 per cent).

Variations in the point of entrance to the transverse foramina were relatively much higher. In my collection of cases there were fifteen such instances, or 37.5 per cent of the cadavers examined. Unilateral variations were almost twice as frequent as bilateral ones; namely, 22.5 per cent and 15 per cent, respectively.

TABLE I.—*Cases where vertebral arteries had the same point of entrance on each side.*

[Six cases, or 15 per cent of those examined.]

| Case No. | Cervical vertebra entered. |
|---|---|
| 14 | Fourth. |
| 22 | Fifth. |
| 1 | Seventh. |
| 4 | Do. |
| 7 | Do. |
| 8 | Do. |

TABLE II.—*Cases where vertebral arteries had a different point of entrance on each side.*

[Nine cases, or 22.5 per cent of those examined.]

| Case No. | Cervical vertebra entered. | |
|---|---|---|
| | Right. | Left. |
| [a]36 | Fourth | Fifth. |
| [a]32 | do | Seventh. |
| [b]39 | Sixth | Third. |
| [b]38 | do | Fifth. |
| 35 | do | Do. |
| 37 | do | Do. |
| [a]28 | do | Seventh. |
| 31 | Seventh | Fifth. |
| 34 | do | Sixth. |

[a] Vertebral artery enters at higher level on left side. It will be noted that these cases constitute one-third of the total number of cases with different points of entrance.

[b] Left vertebral arteries arise from the aortic arch.

## DISCUSSION

The development of the transitory aortic arches of vertebrates was first sketched in the chick by Malpighi, as long ago as 1672, but the earliest work dealing with their development and trans-

formation was done by von Baer(1) in 1827. The last-named author claimed that five pairs of aortic arches were present in the embryos of all vertebrates that developed out of water, but that these were never all present at any one time. Thirty years later Rathke(7) drew up schemes to represent their transformation in Amniota, based upon the assumption that there were only five pairs of these arches represented in the embryonic stage of the higher vertebrates. For a long time the diagrams of Rathke were accepted as standards to represent the history of the development of these arches.

Lehmann(5) says:

> The number of arches recognized by Rathke however was thrown into question by van Bemmelen in 1886, who first pointed out the presence in reptiles and the chick, of a rudimentary arch between the fourth and the supposed fifth. Subsequent observations, notably those of Zimmermann (1889), and Tandler (1902), have led to the recognition of six aortic arches in mammals. The discovery of a rudimentary fifth arch in mammals makes the number of the aortic arches for Amniota the same as in Dipnoi and Amphibia, and establishes an identity, as regards the place of origin of the pulmonary artery in all lung-breathing vertebrates. The diagrams of Boas have accordingly replaced those of Rathke.

Evans,(3) writing in Keibel and Mall's Human Embryology on abnormal aortic branchings, says in part:

> The variations in the great vessels arising from the aortic arch have been known for a long time and could be explained satisfactorily on an embryological basis ever since the work of Rathke. (1843).

To explain my cases of abnormality of origin, it would seem advisable to review the development and transformation of the aortic arches and segmental arteries occurring in normal mammalian embryos (see figs. 1 and 2). In human embryos 4 to 5 millimeters in length five aortic arches are recognized to develop in the following order: First, second, third, fourth, and sixth. The fifth aortic arch is transitory, appearing in embryos 7 millimeters long; it soon degenerates.

Both the descending or dorsal aortæ, between the first and third arches, together with the third aortic arches, give origin to the internal carotid arteries; while the two ventral aortæ, between the third and fourth arches, form the common carotids; those between the first and third arches become the external carotids after the disappearance of the first and second aortic arches. The portion of the dorsal aorta between the third and fourth arches disappears.

The fourth arch, including the short ventral stem between the fourth and sixth arches, becomes the permanent aortic arch

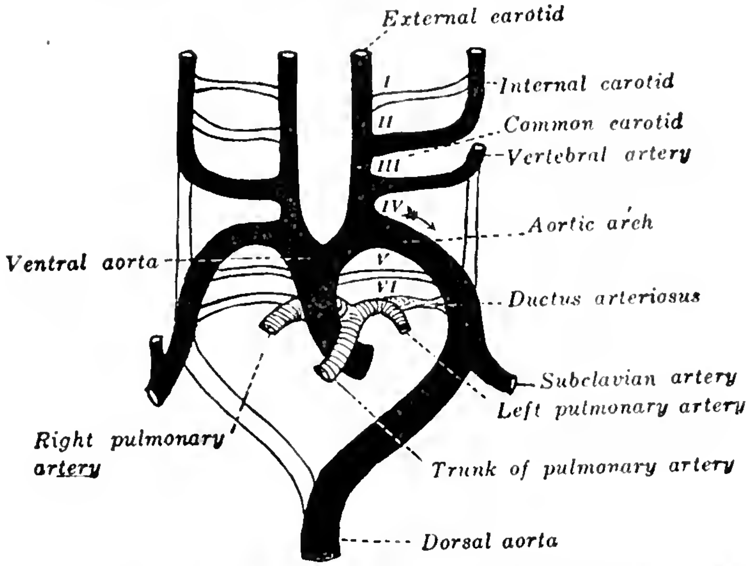



FIG. 1. Diagram, showing the aortic arches and their derivatives in human embryos with normal origin of vertebral arteries (modified after Prentiss).

on the left side, and the innominate and the proximal portion of the subclavian upon the right.

Prentiss(6) says:

The ventral longitudinal anastomosis of the dorsal rami of the first seven pairs of dorsal intersegmental arteries, gives rise to the vertebral

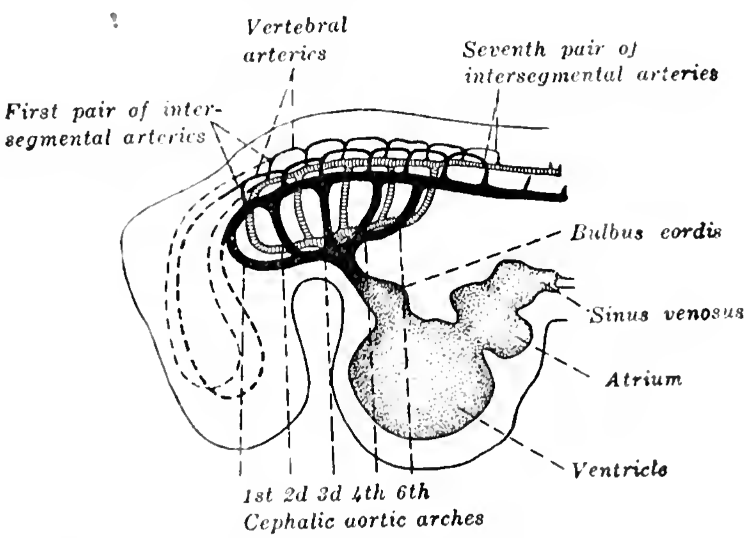



FIG. 2. Diagram, showing stage of five aortic arches and origin of the vertebral arteries (modified after Cunningham).

arteries. The trunks of the first six pairs are lost so that the vertebrals take their origin with the subclavians from the seventh pairs of intersegmental arteries.

Having gained an idea of the normal origin of the vertebral arteries, anatomically and embryologically, three different possibilities would probably account for the abnormal origin of the left vertebral artery as hereinbefore described.

One of the possibilities is the persistence of the second aortic arch in forming the proximal portion of the internal carotid. The ventral aortic stem between the second and third arches takes the place of the left common carotid. The third aortic arch, which eventually becomes the left vertebral artery, shifts downward and laterally comes into direct continuity with the fourth arch, which becomes the future permanent arch of the aorta. Under this possibility it will be seen that the proximal part of the left vertebral artery will be found situated between the left common carotid and the left subclavian artery, as was actually the case in my specimens (see fig. 3).

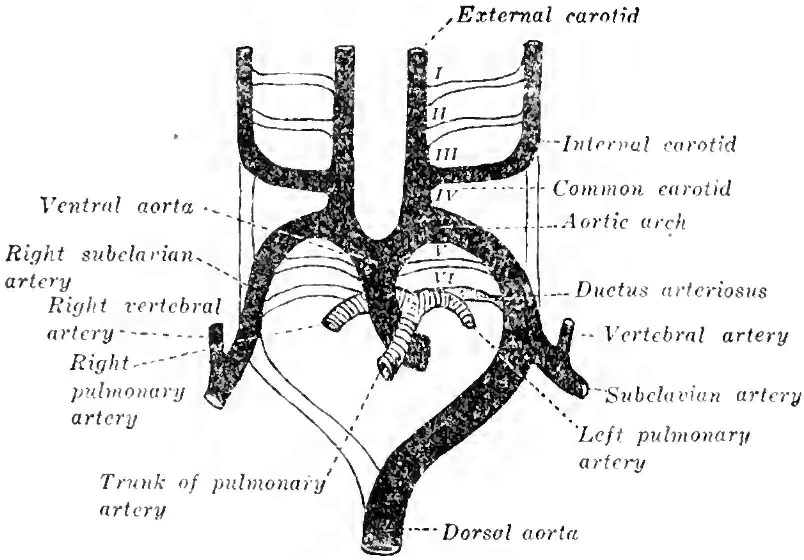



FIG. 3. Diagram, showing one possible abnormal origin of left vertebral artery.

Another not remote possibility would be the persistence of the proximal part of the left dorsal aortic stem between the third and fourth aortic arches and the main trunk of the sixth or one of the more cephalic dorsal intersegmental arteries, the two

together representing the left vertebral artery which, in the final processes of shifting, would come to arise directly from the arch of the aorta between the left common carotid and the left subclavian arteries (see figs. 3 and 4).

A third and last possibility is that the left vertebral artery, instead of arising from the dorsal rami of the seventh intersegmental artery together with the subclavian, originated independently from the sixth intersegmental artery, without the persistence of the proximal part of the dorsal aortic stem between the third and fourth aortic arches if the sixth intersegmental artery was located caudad to them (see figs. 4 and 5).

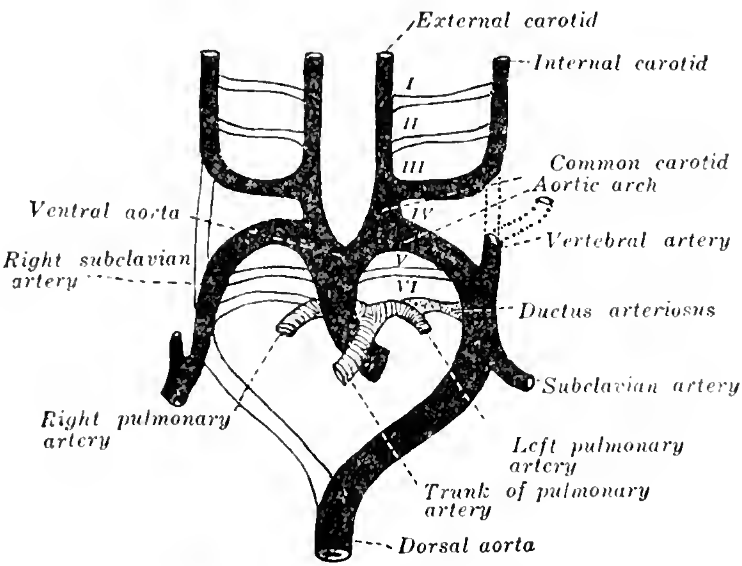



FIG. 4. Diagram, showing another possible abnormal origin of the left vertebral artery.

With regard to the abnormalities in the point of entrance it was found that the foramen transversarium in all the cervical vertebræ below the level of entrance of the vessels was patent.

Keith (4) says that the cervical transverse foramina are produced by perforations of the transverse processes, while still fibrous, by the corresponding intersegmental arteries, the anastomosis of which eventually formed the vertebral artery.

Therefore, in cases where the point of entrance was at an abnormally higher level, it would seem probable that the vertebral artery was formed by fusion of the persisting and corre-

sponding intersegmental artery with the proximal part of the dorsal aortic stem, while the intersegmental arteries below atrophied and disappeared after the formation of the corresponding foramina.

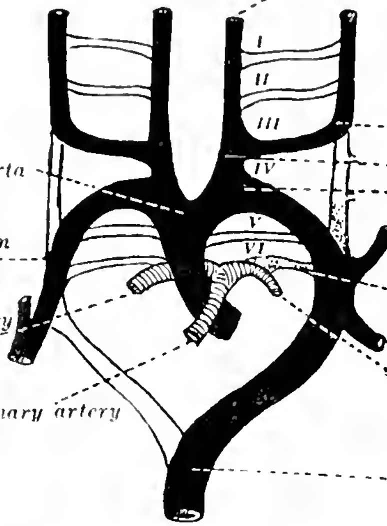



FIG. 5. Diagram, showing possible abnormal origin of left vertebral artery.

SUMMARY

Two of the forty cases showed abnormalities in origin of the vertebral artery; and fifteen, in point of entrance to the foramen transversarium.

My findings confirm those of Bean and Thane with regard to the greater frequency of abnormalities of origin of the vertebral artery in the left side.

Cases of unilateral variations in the point of entrance were almost twice as numerous as the bilateral ones.

My percentages of both abnormalities were higher than those found by Bean.

I am inclined to agree with Bean (p. 313) in ascribing this relatively high percentage of abnormalities of the vertebral artery to the fact that "hybrids tend toward variation." Filipinos undoubtedly must be considered a mixed race.

I wish to acknowledge my indebtedness to Prof. Edward S. Ruth for the helpful suggestions and kindly interest he has given me in this work.

## REFERENCES


1. BAER, K. E. VON. Ueber die Kiemen und Kiemengefässe in den Embryonen der Wirbelthiere. Meckel's Archiv. (1827). Cited by Lehmann, H., Anat. Anz. **26** (1905) 406.
2. BEAN, R. B. A composite study of the subclavian artery in man. *Am. Journ. Anat.* **4** (1905) 309.
3. EVANS, H. M. In Keibel and Mall's Human Embryology. Philadelphia & London, J. B. Lippincott Co. **2** (1912) 630.
4. KEITH, A. Human Embryology and Morphology. London, Edward Arnold (1913) 57.
5. LEHMANN, H. On the embryonic history of the aortic arches in mammals. *Anat. Anz.* **26** (1905) 406 and 407.
6. PRENTISS, C. W. A Laboratory Manual and Text-Book of Embryology. Philadelphia, London, W. B. Saunders Co. (1915) 272.
7. RATHKE, H. Untersuchungen Über die Aortenwurzeln und die von ihnen ausgehenden Arterien der Saurier. *Denksch. d. K. Akad. d. Wiss. Wien* (1857) 13. Cited by Lehmann, H., Anat. Anz. **26** (1905) 406.
8. THANE, G. D. Quain's Elements of Anatomy. London, Longmans, Green & Co. **2** (1899) 387.


167853——4

# ILLUSTRATIONS

## Plate I



### TEXT FIGURES

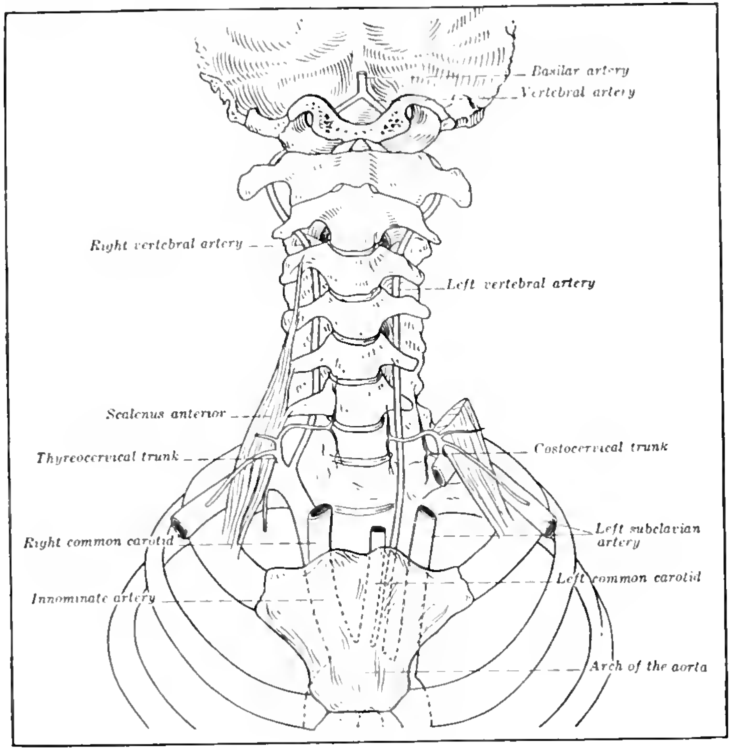



Fig. 1. Left vertebral artery in case 38.

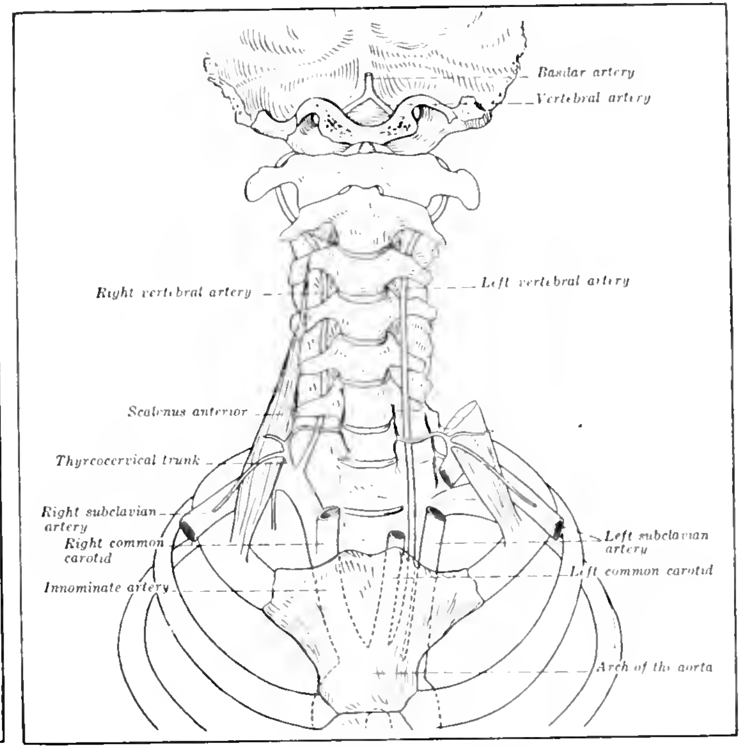



Fig. 2. Left vertebral artery in case 39.

PLATE I.

# THE RANCIDITY OF PHILIPPINE COCONUT OIL

By Granville A. Perkins

*Chemist, Bureau of Science*

In a paper entitled The keeping qualities and the causes of rancidity in coconut oil, H. S. Walker [1] called attention to the ravages of mold on moist copra and impure coconut oil, pointing out that [2]

The action of light and air on coconut oil is of relatively little importance in comparison with the great changes produced by mold growth, and it can be prevented in a large degree by keeping oil receptacles as nearly full as possible, so as to reduce the amount of surface exposed.

He further indicts the molds as follows:

it seems highly probable that these molds produce a slowly acting enzyme, soluble in oil, which continues its hydrolytic action even after the organisms themselves are dead. This would account for the steady increase in free acid of some commercial oils which are perfectly clear and free from impurities and which have been proven to contain no living bacteria or molds. * *

In a later paper, The production of free acid in commercial coconut oil on long standing, Walker [4] gives the following conclusions:

The deterioration of a freshly prepared commercial coconut oil is produced by at least three entirely independent processes and may be divided into two distinct periods of time.

The first, rapid splitting up of the fat, beginning immediately after its expression from copra and continuing for several months up to a year or more according to the nutrive [nutritive] matter present, is occasioned by molds which are either pressed out with the oil together with sufficient sugars and albuminoids for their growth, or, in the case of hot pressed oils, enter the freshly prepared oil from the air. This action continues as long as sufficient nutritive material for mold growth remains in the oil. It may be completely checked by filtration, preferable [preferably] after heating to 100° C. more thoroughly to coagulate albuminoids and to destroy any enzymes already secreted by the molds.

Toward the end of this first period, oxidation by the air sets in and

[1] Philip. Journ. Sci. 1 (1906) 117–172.

[2] Op. cit. 142.

[3] Op. cit. 135.

[4] Philip. Journ. Sci. § A 3 (1908) 126–135.

may continue indefinitely. The rate of this process depends upon the amount of surface exposed to the air, compared with the total volume of oil, and may in extreme cases cause an exceedingly rapid deterioration. It may be entirely prevented by storing the oil in completely filled receptacles, impervious to air.

Along with the two above-mentioned processes, a slight hydrolysis due to heat, moisture and free acids already present is constantly taking place. It may be reduced considerably by filtration, which removes most of the water, together with the organic impurities.

There is reason to believe that some hydrolysis is brought about by enzymes produced by the molds, as unheated oils which have been filtered and rendered antiseptic increase in acidity somewhat more rapidly than do heated ones under the same condtions. However, this distinction is not so apparent after the first year.

Light has apparently no effect on the oxidation by air of coconut oil.

The third and latest paper[5] from the Bureau of Science laboratory on the storage of coconut oil deals chiefly with methods of measuring rancidity. On the subject of the cause of rancidity the authors, besides quoting from Walker and others, make the following observation:[6]

We believe that the nonfatty material in coconut oil has a profound influence on its character, and experiments are now in progress to test this out.

Regarding the nature of rancidity they state:[7]

If the formation of rancidity is caused or accompanied by an oxidation, one of the first changes to take place would be the breaking down of the unsaturated acids into simpler acids * * *.

On the same subject Lewkowitsch[8] comes to the following conclusion:

I therefore define as rancid those oils and fats, the free fatty acids of which have been acted on by the oxygen of the air, in the presence of light. Similar explanations have been given before and the only new element I can claim here would consist in ascribing more emphatically than has been done hitherto the initial phase of rancidity, namely, the hydrolysis, to the accelerating action of enzymes.

The view that light is a necessary condition for rancidity, which Lewkowitsch insists upon, and which he apparently bor-

[5] Brill, H. C., and Parker, H. O., The rancidity of Philippine coconut oil, *Philip. Journ. Sci.* § A 12 (1917) 95–110.

[6] Op. cit. 96.

[7] Op. cit. 108.

[8] Lewkowitsch, J., Chemical Technology and Analysis of Oils, Fats, and Waxes. London, Macmillan & Co. 1 (1913) 52.

A more recent text, Edible Oils and Fats, by C. A. Mitchell, London, Longmans, Green & Co. (1918), presents no new data on this subject.

rowed from Ritsert,[9] is obviously at variance with Walker's conclusions.

Lewkowitsch also points out that the chemical nature of the final products of the rancidity process is still an open question. This phase of the subject is beyond the scope of the present investigation.

The purposes of this article are to present evidence as to the relative effect of various factors in the development of rancidity in edible coconut oil, and to point out wherein this evidence leads to a confirmation, modification, or extension of the above-quoted conceptions of rancidity. The rancidity factors studied were: initial acidity, air, light, moisture, enzymes, and nonfatty material. A discussion of these in detail will be taken up following a description of the storage experiments.

## STORAGE EXPERIMENTS

Samples for the investigation were prepared by Mr. H. O. Parker, of the Bureau of Science, as follows:

Fresh coconut meat was dried in the laboratory and expressed. About 1 liter of practically colorless but cloudy oil was thus obtained, having an acidity of 0.37 per cent. This will be designated as oil A.

Oil A was divided into six parts, which were treated as described in Table I.

TABLE I.—*Treatment of oil before storage.*

| Designation. | Treatment. | Rancidity factors. |
|---|---|---|
| 1 | Filtered clear with fuller's earth | Fat-soluble enzymes. |
| 2 | No. 1 stored with 10 per cent water | Fat-soluble enzymes, moisture. |
| 3 | No treatment | Fat-soluble and -insoluble enzymes (microörganisms), moisture, nonfatty material. |
| 4 | No. 1 sterilized 10 hours at 105° C. | None of the above. |
| 5 | No. 4 stored with 10 per cent water | Moisture. |
| 6 | Sterilized | Moisture and nonfatty material. |

By enzymes and microörganisms are meant only such enzymes and microörganisms as may be present in oil obtained as above described. The term nonfatty material refers to the substances —largely protein and carbohydrate—that, together with moisture, give the cloudy appearance to freshly expressed oil, and which are removed by filtration through fuller's earth.

[9] Ritsert, Untersuchung über d. Ranzigwerden d. Fette, Inaug. Dissert. Berlin (1890).

Each of the six classes of oil A was divided into four parts, of about 30 grams each, and stored March 24, 1917, under the conditions given in Table II.

TABLE II.—*Conditions during storage.*

| Designation. | Conditions. | Rancidity factors. |
| --- | --- | --- |
| Sd | Sealed, kept in the dark |  |
| Sl | Sealed, kept in the diffused light of the laboratory | Light. |
| Od | Open, in the dark | Air. |
| Ol | Open, in the light | Air and light. |

The sealed tubes contained practically no air space (about 0.5 cubic centimeter). The open samples were in 100 cubic centimeter bottles closed only with a cotton plug; in these the oil formed a layer 2 centimeters deep. The temperature during storage was about 30° C.

Another sample of oil, B, was prepared in the same manner as oil A, but was found to have only 0.1 per cent acidity. This was divided into six parts as described in Table I. These were stored on April 19, 1917, exposed to air and light, under the same conditions as series Ol of oil A and will, therefore, be designated as series OlB.

On April 11, 1919, the thirty samples were transferred to glass-stoppered bottles and their examination for rancidity was begun. During the time required for the various determinations, which were made in duplicate, the samples were kept as much as possible in a refrigerator to prevent further change. The results of the examination are given in Table III, in which the first twenty-four samples are from oil A, and the remaining six from oil B.

EXPLANATION OF TABLE III

*Rancidity factors.*—The abbreviations a, l, s, i, m, n, are used to designate air, light, fat-soluble enzymes, fat-insoluble enzymes (together with possible microörganisms), moisture, and nonfatty material, respectively.

*Acidity.*—The first column gives the determinations made by Parker before storing the oil. Evidently sterilization caused a rise from 0.37 to 0.52 in the case of oil A.

*Iodine number.*—The Hanus method was used. Duplicates differed by about 0.04. No data on the original iodine numbers were available, but they may be taken as being close to those of the sealed samples, since the latter had no opportunity of

absorbing oxygen. A sample of oil B which had been sealed and kept in the dark had an iodine number of 6.68. Attention is called to the close correspondence between this figure and the figures given for the OlB series in Table III, showing the remarkable resistance to air and light possessed by the unsaturated glycerides in this oil.

TABLE III.—*Rancidity tests on storage samples.*

| Sample. | Rancidity factors. | Acidity (as oleic). | | | Iodine number. | Fuchsine aldehyde reagent. | Oxidizability value. | Odor. |
|---|---|---|---|---|---|---|---|---|
| | | Original. | Final. | Difference. | | | | |
| | | *Per cent.* | *Per cent.* | *Per cent.* | | | | |
| 1 Sd | s | 0.37 | 0.62 | 0.25 | 6.93 | 1 | 0.6 | 2 |
| 2 Sd | s, m | 0.37 | 0.88 | 0.51 | 6.94 | 1 | 0.6 | 2 |
| 3 Sd | s, i, m, n | 0.37 | 0.79 | 0.42 | 6.90 | 1 | 1.3 | 2 |
| 4 Sd | | 0.52 | 0.63 | 0.11 | 6.92 | 1 | 1.0 | 1 |
| 5 Sd | m | 0.52 | 0.88 | 0.36 | 6.93 | 1 | 1.3 | 2 |
| 6 Sd | m, n | 0.55 | 0.81 | 0.26 | 6.90 | 1 | 1.4 | 2 |
| 1 Sl | l, s | 0.37 | 0.66 | 0.29 | 6.86 | 1 | 0.7 | 2 |
| 2 Sl | l, s, m | 0.37 | 1.09 | 0.72 | 6.93 | 1 | 0.6 | 3 |
| 3 Sl | l, s, i, m, n | 0.37 | 0.85 | 0.48 | 6.88 | 1 | 0.9 | 2 |
| 4 Sl | l | 0.52 | 0.64 | 0.12 | 6.92 | 1 | 0.8 | 2 |
| 5 Sl | l, m | 0.52 | 1.03 | 0.51 | 7.00 | 1 | 0.2 | 3 |
| 6 Sl | l, m, n | 0.55 | 0.76 | 0.21 | 6.95 | 1 | 0.7 | 2 |
| 1 Od | a, s | 0.37 | 0.97 | 0.60 | 6.24 | 5 | 9. | 4 |
| 2 Od | a, s, m | 0.37 | 1.11 | 0.74 | 6.07 | 5 | 10. | 4 |
| 3 Od | a, s, i, m, n | 0.37 | 0.96 | 0.59 | 6.76 | 3 | 2. | 4 |
| 4 Od | a | 0.52 | 0.86 | 0.34 | 6.66 | 4 | 3. | 4 |
| 5 Od | a, m | 0.52 | 0.91 | 0.39 | 6.32 | 5 | 7. | 4 |
| 6 Od | a, m, n | 0.55 | 1.41 | 0.86 | 5.63 | 5 | 16. | 4 |
| 1 Ol | a, l, s | 0.37 | 1.73 | 1.4 | 5.21 | 5 | 18. | 5 |
| 2 Ol | a, l, s, m | 0.37 | 1.84 | 1.5 | 5.20 | 5 | 17. | 5 |
| 3 Ol | a, l, s, i, m, n | 0.37 | 1.74 | 1.4 | 5.22 | 5 | 18. | 5 |
| 4 Ol | a, l | 0.52 | 1.55 | 1.0 | 5.36 | 5 | 21. | 5 |
| 5 Ol | a, l, m | 0.52 | 1.56 | 1.0 | 5.38 | 5 | 20. | 5 |
| 6 Ol | a, l, m, n | 0.55 | 2.15 | 1.6 | 4.97 | 5 | 18. | 5 |
| 1 OlB | a, l, s | 0.1 | 0.15 | 0.05 | 6.71 | 2 | 0.0 | 1 |
| 2 OlB | a, l, s, m | 0.1 | 0.11 | 0.01 | 6.69 | 3 | 1.1 | 2 |
| 3 OlB | a, l, s, i, m, n | 0.1 | 0.21 | 0.11 | 6.66 | 1 | 0.0 | 1 |
| 4 OlB | a, l | 0.1 | 0.11 | 0.01 | 6.68 | 1 | 0.5 | 1 |
| 5 OlB | a, l, m | 0.1 | 0.11 | 0.01 | 6.61 | 2 | 1.0 | 1 |
| 6 OlB | a, l, m, n | 0.1 | 0.18 | 0.07 | 6.67 | 1 | 1.1 | 1 |

*Fuchsine aldehyde reagent.*[10]—Two grams of fuchsine were dissolved in 100 cubic centimeters of cold saturated aqueous solution of sulphur dioxide. This solution was allowed to stand several hours and then diluted to 2,000 cubic centimeters.

[10] Mullikin, Samuel Parsons, Identification of Pure Organic Compounds 1 (1905) 15.

Equal parts of the oil and the reagent were shaken for five seconds in a test tube and allowed to stand two minutes. The colors so produced were, for purposes of comparison, divided into five classes: 1, pale pink; 2, pale violet; 3, medium violet; 4, deeper violet; 5, intense violet.

*Oxidizability value.*—This comparatively new determination was used for confirming rancidity in various oils by Issoglio,[11] who states that edible oils and fats give values of from 3 to 10, while a value above 15 indicates rancidity. From the results of Brill and Parker [12] it appears that 15 is much too high for a sweet coconut oil, but that the test has some value.

For the purposes of the present study it was necessary to modify Issoglio's method somewhat, both because the quantities of oil available were insufficient to supply the 20 to 25 grams demanded by his procedure, and because his method, which uses only one-tenth of the distillate for titration, unduly increases the experimental error. The modified determination was as follows:

About 5 grams of oil and 100 cubic centimeters of recently boiled water were placed in a 500 cubic centimeter distilling flask. The side arm of this flask had been bent in the middle at an angle of about 120°, so that when attached to an ordinary Liebig condenser the neck of the flask was inclined, and the first half of the side arm had sufficient slope to allow any mechanically carried oil to drain back into the flask. The flask was heated, and steam, generated from recently boiled water, was passed through at a rate that gave 100 cubic centimeters of distillate in ten minutes. The 100 cubic centimeters of distillate were treated with 10 cubic centimeters of 20 per cent $H_2SO_4$ and 25 cubic centimeters of 0.02 $N$ $KMnO_4$, then heated to boiling, and boiled five minutes in a 300 cubic centimeter Erlenmeyer flask with a small funnel inserted in the neck. An ebullator tube [13] was used, both to keep the temperature constant, and to prevent loss of vapor by bumping. The flask was allowed to cool to about 70°, and 25 cubic centimeters of 0.02 $N$ oxalic acid were added. The excess oxalic acid was titrated against $KMnO_4$. The oxidizability value, or the number of

[11] Issoglio, G., Ann. chim. applic. 6 (1916) 1–18. Chem. Abs. 10 (1916) 2943.

[12] Philip. Journ. Sci. § A 12 (1917) 106.

[13] A piece of 5 millimeter tubing, long enough to stand upright in the flask, sealed at the upper end and about 15 millimeters from the lower end.

milligrams of oxygen required to oxidize the distillate from 100 grams of oil, was found by the formula,

$$O = \frac{16\,(N-n)}{W},$$

in which $N$ is the number of cubic centimeters of $KMnO_4$ used, $n$ the cubic centimeters of $KMnO_4$ used in blank test, and $W$ the weight of sample.

Duplicates agreed to about 0.4 for values of less than 4. Large values sometimes varied as much as three units.

*Odor.*—Oils designated by 1 had fresh coconut odors which had not, however, quite the intensity of the aroma of a freshly prepared pure oil. Oils designated by 2 were difficult to distinguish from those in class 1. They had a suggestion of staleness, but would not be called rancid. The oils in class 3 had been almost deodorized; they had lost their fresh coconut aroma, but had not acquired more of a stale odor than had those in class 2. Samples 2 Sd and 5 Sd were affected in the same way, but to a less extent.

The oils of class 4 were rancid. They varied somewhat among themselves, 3 Od and 4 Od being the best, and 6 Od the worst; but all possessed a slight odor resembling that of stale lard, which distinguished them from classes 1 to 3, but which was not so strong as that of any in class 5. The oils of class 5 had a fairly strong odor of stale lard.

## RELATIVE EFFECT OF RANCIDITY FACTORS

*Initial acidity.*—It appears from Table III that under the conditions of the experiment a difference between 0.1 per cent and 0.37 per cent original acidity had almost as much effect on the keeping qualities of the oil as all the other influences combined. For only one sample of oil A (4 Sd) had an odor preferable to that sample of oil B (2 OlB) which was stored under the least favorable conditions; and, so far as was known, the two oils A and B were practically identical except for their initial acidity.

From the well-known catalytic effect of acids on hydrolysis and the instability of free unsaturated acids as compared to their glycerides we would expect initial acidity to have a marked effect on the formation of more acidity and rancidity, and this is generally considered to be the case. The effect here indicated,

however, is much greater than that indicated by Walker's[14] results on oils of about the same acidity. The question deserves further investigation as the present study can offer but two oils for comparison, and Walker's results are invalidated, as he says, by the variation in exposure to air.

*Air.*—Table III substantiates the views quoted at the beginning of this article that oxygen is necessary for the development of rancidity but not of acidity. The greater increase of acidity in the open samples was probably due partly to an increased hydrolysis and partly to the breaking up of the oleic acid molecules. The general correspondence of the decrease in the iodine number with the development of rancidity confirms the view quoted from Brill and Parker that the unsaturation of oleic acid offers a point of attack for oxygen in the second stage of rancidity. That this attack is not the initial stage, but is dependent upon some other process, probably hydrolysis, is shown by the remarkable constancy of the iodine number of oil B, even when exposed to air and light.

In this connection a comparison of the decrease in iodine number with the increase of acidity is interesting. A decrease of 1.0 per cent in the iodine number corresponds to the saturation 1.1 per cent of oleic acid. Now in series Od and Ol we have a decrease of iodine number during storage of approximately 0.3 to 2.0 per cent—certainly not less. This corresponds to 0.3 to 2.2 per cent of oleic acid. These calculated values of oleic acid come very close, in each case of series Ol, to the final values found for free acid, but are somewhat less than the final acidity in series Od. In the present state of uncertainty regarding the final products it is difficult to interpret this correspondence. Lewkowitsch[15] seems satisfied that the first stage of rancidity hydrolyzes stearin, palmitin, and olein without selection. If this is true the oxidation (shown by decrease in iodine number) must have attacked *unhydrolyzed olein,* because in the Ol series it affected one-fourth of the total olein present. But Lewkowitsch's prejudice against a possible selective hydrolysis of olein seems based on the experiments of Thum,[16] which are entirely unconvincing, as he merely compared the iodine number of the free fatty acids in each rancid oil to

[14] Philip. Journ. Sci. § A 3 (1908) 133.

[15] Lewkowitsch, J., Chemical Technology and Analysis of Oils, Fats, and Waxes. London, Macmillan & Co. 1 (1913) 55.

[16] Thum, A., Zeits. f. angew. Chem. (1890) 482 and 483 abs. in Journ. Soc. Chem. Ind. (1891) 70.

that of the acids from the neutral fats in the same oil. It seems probable that the free fatty acids had suffered much more oxidation in the process of rancidity than had the unhydrolyzed glycerides. Hence Thum's experimental data tend to disprove his conclusions. The subject requires further investigation.

*Light.*—In view of the results shown in Table III, I cannot subscribe to either of the extreme opinions quoted from Lewkowitsch and Walker, respectively, on the influence of light. On the one hand, the samples of series Od, though kept in darkness, all became rancid; on the other hand, exposure to light had a marked effect. It increased hydrolysis even in the sealed samples, and in two of these (2 Sl and 5 Sl), in conjunction with moisture, it caused a complete loss of fresh-coconut odor. In the open samples of oil A it doubled the hydrolysis, more than doubled the decrease in iodine number, and intensified the rancid odor.

*Enzymes.*—The enzymes mentioned in the quotations from Walker, given early in this article, are those produced by molds. A calculation from his results [17] on the increase of acidity in a sample of oil from moldy copra indicates an enzyme effect in some cases. Fat-soluble enzymes seem to have been responsible for 0.5 per cent acidity increase during the first year and 0.2 per cent during the second. This was in the samples sealed in full bottles. In the half-full bottles no effect can be attributed to fat-soluble enzymes. Practically no effect seems to have been produced by enzymes insoluble in fat.

Lewkowitsch,[18] in placing emphasis on the action of enzymes, calls attention not so much to mold enzymes as to those fat-splitting enzymes which, he says,

> seem to occur in most, if not all, oleaginous seeds, and no doubt play an important part in the utilization of the fatty reserve products stored in the seeds.

The evidence concerning the presence of enzymes in the coconut is somewhat conflicting, but it has been shown in the laboratory [19] of the Bureau of Science that normal coconut meat contains little or no lipase, zymogen, or oxidase. An oxidase was found, however, in coconut *milk*, which accounts for its occasional presence in the oil.

In the present investigation the oils were prepared from fresh, dried coconut meat not appreciably attacked by micro-

[17] Philip. Journ. Sci. § A 3 (1908) 127.

[18] Op. cit. 49.

[19] Brill and Parker, Philip. Journ. Sci. § A 12 (1917) 109.

organisms, thus affording no data concerning enzymes of mold origin. As for the enzymes naturally occurring in coconut meat, it seems evident from Table III that neither the soluble nor the insoluble enzymes played a large part in the deterioration of the oil. A slight effect of the fat-soluble, but not of the fat-insoluble, enzymes may be traced, especially in the column showing the increase in acidity. Unfortunately the enzyme-containing sample must be compared in each case with one of higher initial acidity due to sterilization. In two cases (6 Od and 6 Ol) this higher initial acidity seems to have had a greater effect than the enzymes (3 Od and 3 Ol). On the whole after two years the sterilized oils were little, if any, better than those not sterilized.

*Microörganisms.*—It has been shown by Walker[20] that, although moldy *copra* is responsible for most of the rancidity in commercial coconut oils, and molds will damage a *turbid* oil, yet *filtered* oils are practically unattacked by microörganisms. Any effect of microörganisms shown in this investigation would be found in the unsterilized oils and would therefore be included in the small enzyme effect previously discussed. But since it is unlikely that any mold or bacterial development took place in the filtered oils, we are limited to the apparent effect of the insoluble enzymes, which was zero. It seems improbable that any of the results were affected by microörganisms.

*Moisture.*—The samples of dry oil sealed in glass tubes (1 Sd, 4 Sd, 1 Sl, and 4 Sl) showed an acidity increase of 0.1 to 0.3 per cent. Theoretically this hydrolysis required about 2 to 6 milligrams of water per 30-gram sample. Such small amounts of water may have been present in the oil when sealed, or they may have been formed by decomposition of substances in the oil other than glycerides. When a large excess of water was added the acidity increase was 0.4 to 0.7 per cent, and a deodorization was observed, especially in the samples exposed to light.

In the open samples moisture conditions did not differ much, for all were exposed to normal atmospheric moisture and, on the other hand, all added water evaporated. It must have remained longer in the samples in the dark and assisted in the oxidation, as is evident from the iodine numbers.

*Nonfatty material.*—Examining Table III for the effect of nonfatty material I fail to find any "profound influence." There appears a very slight effect in 3 OlB and 6 OlB, and 6

[20] Philip. Journ. Sci. 1 (1906) 134 and § A 3 (1908) 127.

Od and 6 Ol show a combined effect of increased initial acidity and nonfatty material which is noticeable.

## CONCLUSIONS

Modifying somewhat the conceptions of rancidity outlined at the beginning of this article I submit the following conclusions:

In the type of rancidity of coconut oil studied the first stage is a hydrolysis, the rapidity of which varies with the initial acidity and the amount of moisture present. Exclusive of any mold action, this hydrolysis may be somewhat accelerated by the action of air, light, and a fat-soluble enzyme.

The second stage of rancidity is an oxidation of the free fatty acids. Possibly this involves also the oxidation of unhydrolyzed olein, but the amount of oxidation is dependent on the amount of hydrolysis.

The oxidation is hastened by light and moisture, but light is not a necessary condition.

## CHEMICAL METHODS FOR THE MEASUREMENT OF RANCIDITY

The above conclusions are restricted to the type of rancidity studied. Though this appears to be the common type in coconut oil, the possibility of others is not excluded. Walker [21] describes a "peculiar, pungent, 'strong' odor in otherwise pure oils." I have also observed peculiar odors which the remnants of samples 3 Sd and 5 Sd, not used for analysis, developed during storage for several weeks in a very damp refrigerator. Sample 5 Sd, which developed an odor resembling Roquefort cheese, was found to contain a slight growth of mold, identified by Dr. H. S. Yates, of the Bureau of Science, as a species of *Torula*. No microörganism was found in sample 3 Sd, but it developed a peculiar, acrid odor. When both of these odors had become readily noticeable little or no change could be found in the oxidizability value, fuchsine aldehyde test, or iodine number. The acidity of 3 Sd was 0.87, and that of 5 Sd, 0.95 per cent, only 0.08 and 0.07, respectively, higher than the values previously found.

Such peculiar types of rancidity indicate that a single chemical test cannot be expected to enable one to distinguish between edible and nonedible coconut oils. In the ordinary type of rancidity, however, occurring under the conditions of our investigation, it appears that the decrease in iodine value, the fuchsine aldehyde test, and the oxidizability number give good indica-

[21] Walker, H. S., Philip. Journ. Sci. 1 (1906) 139.

tions of the amount of deterioration. The iodine number alone, without some data on the original number, has no value. The acidity is a measure of the first stage in the rancidity process.

## SUMMARY

Two-year storage tests were made on thirty samples of edible coconut oil. The results were in general agreement with the accepted views of rancidity and its causes. The action of light was found to be a powerful, but not necessary, factor in the production of rancidity. Enzymes from the fresh coconut meat had some effect on the keeping qualities of the oil, but sterilization was of doubtful benefit.

An oil of low initial acidity remained sweet during two years' exposure to air and light.

The measurement of rancidity is discussed briefly.

# THE GENUS GORDONIA IN THE PHILIPPINE ISLANDS

By I. H. Burkill

*Director, Botanic Garden, Singapore*

By the kindness of Mr. E. D. Merrill, I have recently had the loan of the gordonias in the herbarium of the Bureau of Science, Manila. I find five Philippine forms among them, which for the present I call species, though other authors may perhaps not concede more than varietal rank to one, or possibly even two, of them. First of all, there is *Gordonia luzonica* Vidal, a tree so common in the mountains north of Manila Bay that every collector gets it. From these mountains it extends southward, certainly to Negros, and perhaps to Mindanao. Next, in the Mountain Province and in Sorsogon Province, there is a tree with leaves exactly similar, but with a subclavate capsule. This is a form which may be no more than a variety of *G. luzonica*. Thirdly, in the northern part of Luzon, there is the species (*Curran 5083*) to which I previously called attention, under *G. luzonica*,[1] with larger leaves and capsules and with a considerable amount of hair upon the midrib on the lower surface of the leaves. Fourthly, on Mount Polis, which is also in northern Luzon, there is a species clearly distinct in flowers and capsules from all other Philippine forms. Lastly, there is a montane plant with entire leaves on Mount Sablayan, Mindoro.

I propose to name these, respectively, (1) *Gordonia luzonica*, (2) *G. subclavata*, (3) *G. benguetica*, and (4) *G. polisana*, leaving the fifth without a name because it is too imperfectly known.

*Key to the Philippine Gordonias.*

$a^1$. Leaves dentate.
- $b^1$. Leaves narrowed to the acumen, about one-third as broad as long.
  - $c^1$. Capsules 3 to 4 cm long, thickest below the middle, pyramidal at the top ........ 1. G. luzonica.
  - $c^2$. Capsules 4 cm long, subclavate, the top domed 2. G. subclavata.
- $b^2$. Leaves rounded under the acumen, about one-half as broad as long.
  - $c^3$. Leaves broadest at the middle; capsule 4 cm long. 3. G. benguetica.

[1] Journ. Straits Branch Roy. Asiat. Soc. 76 (1917) 150.

c[3]. Leaves broadest above the middle; capsule long-tapering.
4. G. polisana.

a[1]. Leaves entire .................... 5. G. sp. (*Merritt 9757*).

It will be observed that I have not included *G. welborni* Elmer, from Negros, because I see no difference between it and *G. luzonica*, nor *G. fragrans* Merr., which Mr. Merrill has already reduced to the same species.[2]

*Gordonia luzonica* in the Manila herbarium is represented from Mount Mariveles, Bataan Province, by the following specimens: *Merrill 3732*, *Whitford 305*, *For. Bur. 809 Borden*, *Williams 747*, *For. Bur. 236 Meyer*, and *For. Bur. 6229 Curran*, collected at varying heights between 600 and 1,500 meters above sea level. The trees are recorded as from 6 to 20 meters high with a diameter at breast height of 30 to 100 cm. Meyer states that it is very common. Evidently it occurs as isolated individuals upon ridges and exposed slopes. Just north of Bataan, in Zambales Province, Ramos collected it as a rather small tree at Tapotas, *Bur. Sci. 5091 Ramos*. In Laguna Province it occurs at Paete, *Bur. Sci. 5077 McGregor* and *Bur. Sci. 10029 Ramos;* at Papatakem, *Merrill Phil. Pl. 428, coll. Ramos*, and on Mount Banahao, *Bur. Sci. 27939 Ocampo*. The recorded altitudes vary from 100 to 1,376 meters. The height recorded for the trees is from 28 to 30 meters with a diameter at breast height up to 117 cm. It was also collected on Mount Banahao by Vidal, the altitude given as 600 to 1,000 meters. The Cuernos Mountains where Mr. Elmer secured his *G. welborni*, *Elmer 9584*, are in the southern part of Negros; Mount Silay where Mr. Whitford has gathered the species (*No. 1499*) is in the northern part of the same island. The altitude on Mount Silay is recorded as 1,044 to 1,135 meters; that on the Cuernos Mountains as 1,300 meters. Mr. Elmer records trees as reaching the height of 50 meters, or 160 feet. The statement that this species occurs in Mindanao rests upon fallen corollas only, and therefore is not to be reckoned as well founded. These fallen corollas were picked up by Mrs. Clemens at Camp Keithley on Lake Lanao.

The flowering period of *G. luzonica* must be as extended as is that of the Singapore gordonias. On Mount Mariveles flowers have been secured in January, February, and March; in Laguna Province, in May, July, and August; in Negros, in May and June; and in Mindanao, in July. The flowers are white and fragrant.

[2] Philip. Journ. Sci. 3 (1908) Bot. 114.

*Gordonia luzonica* has been too little collected in fruit; and, though there is a slightly different facies about *G. subclavata*, the line between them needs defining upon more ample material than is now available.

*Gordonia subclavata* was collected at Bauco, Bontoc Subprovince, by *Vanoverbergh (No. 1465)*, with fruit, in September or October; and by *Ramos (Bur. Sci. 23391)* on Mount Lalao, Sorsogon Province, with fruit, in August. The two localities are far apart; but the specimens are an exact match. The altitude at which the first was collected is 1,700 meters and that of the second about 300 meters. The height of the tree in the first is recorded as 3 or 4 meters; in the second, as about 20 meters.

As stated above, *Gordonia benguetica* has been collected but once. This was at Baguio along a stream depression at an altitude of about 1,200 meters. The tree was 4 meters high, and had flower buds as well as ripe capsules. The leaves are large, exactly rounded above under the mucro, and conspicuously toothed along the margins; the veins are fairly evident to the eye, while the midrib at the back, especially toward the base, is clothed with silky hairs. It is very desirable that more material of this species be collected; for, although the shape of the leaf is so distinct from that of *G. luzonica* as to render it impossible to look upon it—a small tree—as immature *G. luzonica*, one gathering is less than is desirable for the defining of the species.

*Gordonia polisana* is a quite distinct species. It has been collected twice upon Mount Polis in Bontoc Subprovince, *For. Bur. 18384 Alvarez*, and *Sandkuhl 316*, both times in the month of January, and both times with flowers. These flowers are very large—Mr. Sandkuhl says 11 to 14 cm across—and dried they measure 9 cm. The flowers are white. The tree is recorded as from 10 to 15 meters high, and as growing in the mossy forest or just below it from 1,500 to 1,600 meters' altitude. A broken-up capsule was secured by Sandkuhl, and it is obvious that it tapers gradually after the manner of *G. penangensis*.

The remaining species, that represented by *For Bur. 9757 Merritt*, has rather small entire leaves and the appearance of having been wind swept. Doubtless it occurs on the margin of stunted vegetation, although the altitude is given as 1,000 me-

ters. Buds are present upon the specimen, which was collected in the month of March.

1. GORDONIA LUZONICA Vidal Rev. Pl. Vasc. Filip. (1886) 57.

*Gordonia fragrans* Merrill in Philip. Journ. Sci. 1 (1906) Suppl. 95.
*Gordonia welborni* Elmer, Leafl. Philip. Bot. 2 (1908) 501.

Arbor ad 50 m alta. Folia oblongo-lanceolata, triplo longiora quam latiora, in petiolo brevi angustata, in acumen gradatim acuminata, maturitate clava. Flores ad 5 cm diametro. Capsulae 3 ad 4 cm longae, infra medium crassiores, apice pyramidales.

Crescit in montibus insularum Luzon, Negros et forsan Mindanao, locis plurimis.

2. GORDONIA SUBCLAVATA sp. nov., vel forsan praecedentis varietas.

Arbor ad 20 m alta. Folia oblongo-lanceolata, triplo longiora quam latiora, in petiolo brevi angustata, in acumen gradatim acuminata, maturitate calva. Flores ad 5 cm diametro. Capsulae 4 cm longae, supra medium crassiores, apice hemisphaericae.

Crescit in montibus subprovinciae Bontoc ad Bauco, et provinciae Sorsogon in monte Lalao, insulae Luzon.

3. GORDONIA BENGUETICA sp. nov.

Arbor ad 4 m alta. Folia late elliptica, duplo longiora quam latiora, versus petiolum brevem cuneata, versus acumen rotundata, infra in nervo medio pubescentia. Flores igniti. Capsulae 4 cm longae, ad medium vel infra medium crassiores, apice pyramidales.

Crescit in vallículis montium prope Baguio, insulae Luzon.

4. GORDONIA POLISANA sp. nov.

Arbor ad 15 m alta. Folia obovata vel elliptico-obovata, duplo longiora quam latiora, sessilia, versus insertionem cuneata, versus acumen rotundata, maturitate calva. Flores ad 9 vel ad 14 cm diametro. Capsulae 4 cm longae, angustae, acutae.

Crescit in monte Polis, districtu Ifugao, insulae Luzon.

5. GORDONIA sp.

Arbor ad 12 m alta. Folia fere exacte elliptica vel elliptico-obovata, integra, in petiolo brevi angustata, sub acumine rotundata, maturitate calva. Flores, ut dicitur, virides.

Collegit M. L. Merritt sub numero 9757 in Monte Sablayan, insulae Mindoro.

# HIGHER BASIDIOMYCETES FROM THE PHILIPPINES AND THEIR HOSTS, I

By O. A. Reinking

*Plant Pathologist of the College of Agriculture and of the Agricultural Experiment Station, Los Baños, P. I.*

An attempt has been made to collect the higher Basidiomycetes of the Philippine Islands from known hosts. Few collections of the fleshy and woody fungi in the Philippines or in other countries have been made with a view to determining the trees attacked. Miscellaneous collections of such fungi are currently made by dumping them into a sack and later separating them and sending them away for determination. While it is absolutely impossible to give the hosts in each instance, because of their decayed condition, determination of a large number of species was accomplished by examination of wood sections. I am indebted to the Bureau of Forestry for the majority of the wood determinations. In a study of forest-tree- and timber-destroying fungi, it is of the utmost importance first to become acquainted with the flora in the forest and then to know whether or not a particular fungus is confined to a definite plant. A survey of these fungi has shown that the vast majority found on dead wood are not confined to specific plants. Most of the species will grow equally well on a large number of woods. The parasitic ones apparently are more apt to be confined to definite hosts.

The species of this list are grouped, in so far as possible, according to the classification of Engler and Prantl with the host and the collector under each class of fungus. The numbers refer to the College of Agriculture fungus herbarium. The collections have been made on Mount Maquiling and in the vicinity of Los Baños, Laguna Province, Luzon, in Mindanao, and in Sulu, either by me or by my students under my direction as indicated in the text. The identifications of the fungi in this list were made by N. Patouillard, of Neuilly sur Seine, France.

## AURICULARIACEAE

### AURICULARIA Bulliard

AURICULARIA AURICULA-JUDAE (L.) Schroet.

*Furcraea gigantea* Vent., Mount Maquiling, *Reinking 1917*, on dead leaves.

AURICULARIA MESENTERICA (Dicks.) Fries.

*Celtis philippensis* Blanco, Mount Maquiling, *Collado 1418*, on dead branches.

*Cordia myxa* L., Mount Maquiling, *Collado 1807*, on dead branches.

*Leucaena glauca* (L.) Benth., Mount Maquiling, *Collado 1876*, on dead stump.

*Premna odorata* Blanco, Mount Maquiling, *Lontok 1020*, on dead branches.

*Theobroma cacao* L., Los Baños, *Baybay 759*, on dead branches.

AURICULARIA POLYTRICHA (Mont.) Saccardo.

*Aleurites moluccana* (L.) Willd., *Collado 48*, on dead branches.

*Castilloa elastica* Cerv., Basilan, Isabela, *Reinking 2081, 2077*, on dead logs and branches.

*Cordia myxa* L., Mount Maquiling, *Collado 70*, on living bark.

*Hevea brasiliensis* (HBK) Muell.-Arg., Basilan, Isabela, *Reinking 2060*, on dead branches.

*Mangifera indica* L., Los Baños, *Marquez 255, Hernandez 840, 957*, on dead branches.

*Parkia javanica* (Lam.) Merr. (*Parkia roxburghii* G. Don), Mount Maquiling, *Leaño 601*, on living bark.

AURICULARIA TENUIS Léveillé.

*Columbia serratifolia* (Cav.) DC., Mount Maquiling, *Collado 1453*, on dead stem.

*Cratoxylon* sp., Mount Maquiling, *Collado 1374*, on dead branches.

*Diospyros* sp., Mount Maquiling, *Collado 1470*, on dead branches.

*Diplodiscus paniculatus* Turcz., Mount Maquiling, *Collado 1342*, on dead branches.

*Ficus* sp., Mount Maquiling, *Collado 1426*, on dead branches.

*Leucaena glauca* (L.) Benth., Mount Maquiling, *Collado 1414*, on dead branches.

*Meliaceae* indet., Mount Maquiling, *Reinking 90*, on dead branches.

*Parinarium* sp., Mount Maquiling, *Collado 71*, on dead branches.

*Psidium guajara* L., Mount Maquiling, *Collado 51*, on dead branches.

*Pterocarpus* sp., Mount Maquiling, *Collado 1434*, on dead branches.

## TREMELLACEAE

### HETEROCHAETE Patouillard

HETEROCHAETE TENUICULA (Lév.) Patouillard.

*Cajanus cajan* (L.) Millsp., Mount Maquiling, *Reinking 1938*, on dead branches.

*Hevea brasiliensis* (HBK) Muell.-Arg., Basilan, Isabela, *Reinking 2032*, on dead branches.

*Siphonodon celastrineus* Griff., Mount Maquiling, *Alcasid 265, 266*, on dead branches.

## DACRYOMYCETACEAE

### GUEPINIOPSIS Patouillard

GUEPINIOPSIS SPATHULARIUS (Schw.) Patouillard.

*Bambusa spinosa* Roxb. (*Bambusa blumeana* Schultes), Los Baños, *Pañganiban 356*, on dead culm.

## THELEPHORACEAE

### HYMENOCHAETE Léveillé

HYMENOCHAETE ADUSTA (Lév.) Bresadola.

Mount Maquiling, *Collado 131*, on decaying log.

HYMENOCHAETE ATTENUATA Léveillé.

*Leucaena glauca* (L.) Benth., Mount Maquiling, *Collado 1474*, on dead branches.

HYMENOCHAETE PAVONIA Patouillard.

*Antidesma bunius* (L.) Spreng., Los Baños, *Estrebillo 650*, on living leaves.

HYMENOCHAETE PERPUSILLA Patouillard.

*Heritiera littoralis* Dry., Mount Maquiling, *Cabanos 784*, on living leaves.

### CLADODERRIS Persoon

CLADODERRIS DENDRITICA Persoon.

*Ficus* sp., Mount Maquiling, *Collado 1480*, on dead stems.

*Hevea brasiliensis* (HBK) Muell.-Arg., Basilan, Isabela, *Reinking 2037*, on dead stems.

Los Baños, *Marquez 1085*, on the ground.

## POLYPORACEAE

### GANODERMA Karsten

GANODERMA LUCIDUM (Leys.) Karsten.

*Bambusa spinosa* Roxb. (*Bambusa blumeana* Schultes), Mount Maquiling, *Collado 2349*, on dead stems.

GANODERMA LUCIDUM (Leys.) Karst. var. LACCATUM Patouillard.

*Dracontomelum dao* Merr. et Rolfe, Mount Maquiling, *Reinking 2080*, on living roots.

### POLYPORUS Micheli

POLYPORUS LIGNOSUS (Kl.) Bresadola.

*Ficus* sp., Mount Maquiling, *Catalan 2345*, on dead stems.

POLYPORUS RUGULOSUS Léveillé.

*Mangifera indica* L., Laguna Province, San Antonio, *Hernandez 1089*, on dead stems.

*Theobroma cacao* L., Mount Maquiling, *Sobrepeña 1180*, on dead stems.

### TRAMETES Fries

TRAMETES ASPERA (Jungh.) Bresadola.

*Elaeocarpus* sp., Mount Maquiling, *Collado 1452*, on dead branches.

*Ficus* sp., Mount Maquiling, *Collado 1392*, on dead stems.

TRAMETES BADIA Berkeley.

*Parkia javanica* (Lam.) Merr. (*P. roxburghii* G. Don), Mount Maquiling, *Leaño 602*, on dead wood.

TRAMETES FLAVA (Jungh.) Patouillard.

*Terminalia comintana* Merr., Mount Maquiling, *Collado 94*, on dead stems.

TRAMETES PERSOONII Montagne.

*Aleurites moluccana* (L.) Willd., Mount Maquiling, *Collado 52*, on dead branches.

*Antiaris* sp., Mount Maquiling, *Collado 1466*, on dead branches.

*Ficus* sp., Mount Maquiling, *Collado 730*, on dead stems.

*Ficus religiosa* L., Mount Maquiling, *Pañganiban 310*, on dead branches.

*Hevea brasiliensis* (HBK) Muell.-Arg., Basilan, Isabela, *Reinking 2034, 2035*, on dead branches.

*Pterocymbium tinctorium* Merr., Mount Maquiling, *Collado 50*, on dead stems.

TRAMETES SCOPULOSA (Berk.) Bresadola.

*Ficus* sp., Mount Maquiling, *Collado 1462*, on dead stems.

## LENZITES Fries

LENZITES APPLANATA Fries.

*Prosopis vidaliana* Naves, Mount Maquiling, *Lontok 2310*, on dead stems.

LENZITES PALISOTI Fries.

*Acacia farnesiana* (L.) Willd., Mount Maquiling, *Collado 45*, on dead stems.

*Celtis philippensis* Blanco, Mount Maquiling, *Collado 1418*, on dead stems.

*Ficus* sp., Mount Maquiling, *Collado 2346*, on dead wood.

*Leucaena glauca* (L.) Benth., Mount Maquiling, *Collado 2348*, on dead stems.

*Mallotus* sp., Mount Maquiling, *Collado 1482*, on dead stems.

*Mangifera indica* L., Los Baños, *Hernandez 929*, on dead stem.

*Parkia javanica* (Lam.) Merr. (*P. roxburghii* G. Don), Mount Maquiling, *Leaño 1011*, on dead bark.

LENZITES PLATYPHYLLA Léveillé.

*Bambusa spinosa* Roxb. (*Bambusa blumeana* Schultes), Los Baños, *Marquez 256*, on dead stems.

LENZITES TENUIS Berkeley.

*Bambusa spinosa* Roxb. (*Bambusa blumeana* Schultes), Los Baños, *Collado 1837*, on dead culm.

*Leucaena glauca* (L.) Benth., Los Baños, *Collado 1854*, on dead branches.

*Musa sapientum* L., Los Baños, *Reyes 2358*, on partly dead leaf.

## HEXAGONA Fries

HEXAGONA THWAITESII Berkeley.

*Hevea brasiliensis* (HBK) Muell.-Arg., Basilan, Isabela, *Reinking 2021*, on dead branches.

*Leucaena glauca* (L.) Benth., Mount Maquiling, *Collado 1456*, on dead branches.

*Macaranga tanarius* (L.) Muell.-Arg., Mount Maquiling, *Navera 794*, on dead twig.

*Mangifera indica* L., Mount Maquiling, *Torres 1188*, *Hernandez 960*, on dead branches.

HEXAGONA THWAITESII Berk. var. RETROPICTA Bresadola.

*Parkia javanica* (Lam.) Merr. (*P. roxburghii* G. Don), Mount Maquiling, *Reinking 1999*, on dead wood cuttings.

### FAVOLUS Fries

FAVOLUS PHILIPPINENSIS Berkeley.

*Mallotus* sp., Mount Maquiling, *Collado 1396*, on dead branches.

FAVOLUS SPATHULATUS (Jungh.) Bresadola.

*Bambusa spinosa* Roxb. (*Bambusa blumeana* Schultes), Mount Maquiling, *Albano 589*, on dead culms.

FAVOLUS TENER Léveillé.

*Hevea brasiliensis* (HBK) Muell.-Arg., Basilan, Isabela, *Reinking 2070*, on dead branch.

### CYCLOMYCES Kunze

CYCLOMYCES CICHORIACEUS (Berk.) Patouillard.

*Psidium guajava* L., Mount Maquiling, *Collado 1384*, on dead branches.

CYCLOMYCES TABACINUS (Mont.) Patouillard.

*Quercus* sp., Mount Maquiling, *Collado 41, 43, 1488*, on dead branches.

### LEUCOPORUS Quelet

LEUCOPORUS GALLO-PAVONIS (Berk.) Patouillard.

*Ficus* sp., Mount Maquiling, *Collado 1469*, on dead branches.

LEUCOPORUS GRAMMOCEPHALUS (Berk.) Patouillard.

*Columbia serratifolia* (Cav.) DC., Mount Maquiling, *Collado 1443*, on dead branches.

### MELANOPUS Patouillard

MELANOPUS GUILFOLEYI (Berk.) Patouillard.

Mount Maquiling, *Collado 1476*, on dead wood.

### MICROPORUS Palisot de Beauvois

MICROPORUS AFFINIS (Nees) Patouillard.

*Dillenia* sp., Mount Maquiling, *Collado 1358*, on dead branches.
*Trema* sp., Mount Maquiling, *Collado 1454*, on dead branches.

MICROPORUS CRENATUS (Berk.) Patouillard.

Mount Maquiling, *Collado 138*, on bark of a tree.

MICROPORUS MICROLOMA (Lév.) Patouillard.

*Cordia* sp., Mount Maquiling, *Rieafrente 1366*, on dead branches.

MICROPORUS SANGUINEUS (Lév.) Patouillard.

*Alstonia macrophylla* Wall., Mount Maquiling, *Collado 1458*, on dead branches.

*Koordersiodendron pinnatum* Merr., Mount Maquiling, *Collado 1494*, on dead branches.

*Mangifera indica* L., Mount Maquiling, *Collado 1338*, on dead branches.

MICROPORUS XANTHOPUS (Fr.) Patouillard.

*Aleurites moluccana* (L.) Willd., Mount Maquiling, *Collado 84*, on decaying wood.

*Cratoxylon* sp., Mount Maquiling, *Collado 1347*, on dead branches.

*Leucaena glauca* (L.) Benth., Mount Maquiling, *Collado 774*, on dead branches.

*Morus alba* L., Mount Maquiling, *Collado 140*, on dead branches.

*Psidium guajava* L., Mount Maquiling, *Collado 1834*, on dead branch.

*Quercus* sp., Mount Maquiling, *Collado 1364*, on dead branches.

CORIOLUS Quelet

CORIOLUS HIRSUTUS (Fr.) Quelet.

*Cassia grandis* L., Mount Maquiling, *Dario 1163*, on dead branches.

*Litsea* sp., Mount Maquiling, *Reinking 1471*, on dead branches

*Mangifera caesia* Jack, Jolo Provincial School Nursery, *Reinking 2160*, on dead branches.

*Parashorea plicata* Brandis, Mount Maquiling, *Collado 1499*, on dead branches.

*Parkia javanica* (Lam.) Merr. (*P. roxburghii* G. Don), Mount Maquiling, *Collado 1339*, on dead branches.

## AGARICACEAE

SCHIZOPHYLLUM Fries

SCHIZOPHYLLUM COMMUNE Fries.

*Bauhinia* sp., Mount Maquiling, *Collado 89*, on dead stem.

*Castilloa elastica* Cerv., Basilan, Isabela, *Reinking 2075*, on dead branches.

*Celtis philippensis* Blanco, Mount Maquiling, *Collado 1413*, on dead branches.

*Hevea brasiliensis* (HBK) Muell.-Arg., Basilan, Isabela, *Reinking, 2040, 2049*, on dead stump.

*Ipomoea batatas* (L.) Poir., Mindanao, Momungan Colony, *Reinking 2095*, on dead root.

*Leucaena glauca* (L.) Benth., Mount Maquiling, *Collado 1420, 1436, Navera 258*, on dead branches.

*Luffa cylindrica* Roem., Los Baños, *Bautista 305*, on living stems.

*Mangifera indica* L., San Antonio, *Hernandez 1049*, on dead branches.

*Musa sapientum* L., San Antonio, *Reyes 746*, on dead leaf sheath.

*Prosopis vidaliana* Naves, Mount Maquiling, *Lontok 944, 1067*, on dead branches.

*Saccharum officinarum* L., Mount Maquiling, *Serrano 1039, Pañganiban 343*, on dead stems.

*Sapium merrillianum* Pax et K. Hoffm., Mount Maquiling, *Collado 1404*, on dead branches.

*Schizostachyum* sp., Mount Maquiling, *Albano 831*, on dead stem.

*Tamarindus indica* L., Mount Maquiling, *Alcasid 495*, on dead branches.

*Zea mays* L., Mount Maquiling, *Bautista 365*, on dead stem.

### LENTINUS Fries

LENTINUS CONNATUS Berkeley.

Mount Maquiling, *Collado 112, 1464*, on decaying log.

LENTINUS DACTYLIOPHORUS Léveillé.

Mount Maquiling, *Collado 1838*, on decaying log.

LENTINUS DICHROUS Léveillé.

Mount Maquiling, *Collado 1360, 1386*, on dead wood.

LENTINUS EXILIS Klotzsch.

*Bambusa spinosa* Roxb. (*Bambusa blumeana* Schultes), Mount Maquiling, *Collado 508*, on dead culm.

### MARASMIUS Fries

MARASMIUS PILOPUS Kalchbrenner.

*Mallotus* sp., Mount Maquiling, *Collado 1406*, on dead branches.

### CRINIPELLIS Patouillard

**CRINIPELLIS GALEATUS** (Berk. et Curt.) Patouillard.

*Citrus nobilis* Lour., Los Baños, *Lindayag 990*, on dead stem.

**CRINIPELLIS STIPITARIUS** (Fr.) Patouillard.

Mount Maquiling, *Collado 1350*, on dead wood.

## LYCOPERDACEAE

### LYCOPERDON Tournefort

**LYCOPERDON POLYMORPHUM** Vittadini.

*Arenga pinnata* (Wurmb) Merr. (*Arenga saccharifera* Labill.), Mount Maquiling, *Peralta 201*, on dead parts.

**LYCOPERDON ROSEUM** Zoll.

*Leucaena glauca* (L.) Benth., Mount Maquiling, *Collado 1420*, on dead branches.

*Memecylon* sp., Mount Maquiling, *Bautista 1328*, on dead stem.

### GEASTER Micheli

**GEASTER VELUTINUS** Lloyd.

Mount Maquiling, *Cazeñas 796*, on dead wood.

## FUNGI LISTED ACCORDING TO HOSTS

ACACIA FARNESIANA (L.) Willd.
*Lenzites palisoti* Fr., dead branches.

ALEURITES MOLUCCANA (L.) Willd.
*Auricularia polytricha* (Mont.) Sacc., dead branches.
*Microporus xanthopus* (Fr.) Pat., decaying wood.
*Trametes persoonii* Mont., dead branches.

ALSTONIA MACROPHYLLA Wall.
*Microporus sanguineus* (Lév.) Pat., dead branches.

ANTIARIS sp.
*Trametes persoonii* Mont.

ANTIDESMA BUNIUS (L.) Spreng.
*Hymenochaete pavonia* Pat., living leaves.

ARENGA PINNATA (Wurmb) Merr. (*Arenga saccharifera* Labill.).
*Lycoperdon polymorphum* Vitt., dead parts.

BAMBUSA SPINOSA Roxb. (*Bambusa blumeana* Schultes).
*Favolus spathulatus* (Jungh.) Bres., dead culms.
*Ganoderma lucidum* (Leys.) Karst., dead culm.
*Guepiniopsis spathularius* (Schw.) Pat., dead culm.
*Lentinus exilis* Kl., dead culm.
*Lenzites platyphylla* Lev., dead culm.
*Lenzites tenue* Berk., dead culm.

BAUHINIA sp.
*Schizophyllum commune* Fr., dead stem.

CAJANUS CAJAN (L.) Millsp.
*Heterochaete tenuicula* (Lev.) Pat., dead branches.

CASSIA GRANDIS L.
*Coriolus hirsutus* (Fr.) Quel., dead branches.

CASTILLOA ELASTICA Cerv.
*Auricularia polytricha* (Mont.) Sacc., dead log.
*Schizophyllum commune* Fr., dead branches.

CELTIS PHILIPPENSIS Blanco.
*Auricularia mesenterica* (Dicks.) Fr., dead branches.
*Lenzites palisoti* Fr., dead branches.
*Schizophyllum commune* Fr., dead branches.

CITRUS NOBILIS Lour.
*Crinipellis galeatus* (B. et Curt.) Pat., dead stem.

COLUMBIA SERRATIFOLIA (Cav.) DC.
*Auricularia tenuis* Lév., dead stem.
*Leucoporus grammocephalus* (Berk.) Pat., dead branches.

CORDIA sp.
*Microporus microloma* (Lév.) Pat., dead branches.

CORDIA MYXA L.
*Auricularia mesenterica* (Dicks.) Fr., dead branches.
*Auricularia polytricha* (Mont.) Sacc., bark of living tree.

CRATOXYLON sp.
*Auricularia tenuis* Lév., dead branches.
*Microporus xanthopus* (Fr.) Pat., dead branches.

DILLENIA sp.
*Microporus affinis* (Nees) Pat., dead branches.

DIOSPYROS sp.
*Auricularia tenuis* Lév., dead branches.

DIPLODISCUS PANICULATUS Turcz.
*Auricularia tenuis* Lév., dead branches.

DRACONTOMELUM DAO (Blanco) Merr. et Rolfe.
*Ganoderma lucidum* (Leys.) Karst. var. *laccatum* Pat., living roots.

ELAEOCARPUS sp.
*Trametes aspera* (Jungh.) Bres.

FICUS spp.
*Auricularia tenuis* Lév., dead branches.
*Cladoderris dendritica* Pers., dead branches.
*Lenzites palisoti* Fr., dead branches.
*Leucoporus gallo-pavonis* (Berk.) Pat., dead branches.
*Polyporus lignosus* Kl., dead branches.
*Trametes aspera* (Jungh.) Bres., dead branches.
*Trametes persoonii* Mont., dead branches.
*Trametes scapulosa* (Berk.) Bres., dead branches.

FICUS RELIGIOSA L.
*Trametes persoonii* Mont., dead branches.

FURCRAEA GIGANTEA Vent.
*Auricularia auricula-judae* (L.) Schroet., dead leaves.

HERITIERA LITTORALIS Dry.

*Hymenochaete perpusilla* Pat., living leaves.

HEVEA BRASILIENSIS (HBK) Muell.-Arg.

*Auricularia polytricha* (Mont.) Sacc., dead branches.
*Cladoderris dendritica* Pers., dead branches.
*Favolus tener* Lév., dead branch.
*Heterochaete tenuicula* (Lév.) Pat., dead branches.
*Hexagona thwaitesii* Berk., dead branches.
*Schizophyllum commune* Fr., dead stump.
*Trametes persoonii* Mont., dead branches.

IPOMOEA BATATAS (L.) Poir.

*Schizophyllum commune* Fr., dead root.

KOORDERSIODENDRON PINNATUM Merr.

*Microporus sanguineus* (Lév.) Pat., dead branches.

LEUCAENA GLAUCA (L.) Benth.

*Auricularia mesenterica* (Dicks.) Fr., dead stump.
*Auricularia tenuis* Lév., dead branches.
*Hexagona thwaitesii* Berk., dead branches.
*Hymenochaete attenuata* Lév., dead branches.
*Lenzites palisoti* Fr., dead branches.
*Lenzites tenuis* Berk., dead branches.
*Lycoperdon roseum* Zoll., dead branches.
*Microporus xanthopus* (Fr.) Pat., dead branches.
*Schizophyllum commune* Fr., dead branches.

LITSEA sp.

*Coriolus hirsutus* (Fr.) Quel., dead branches.

LUFFA CYLINDRICA (Linn.) Roem.

*Schizophyllum commune* Fr., living stems.

MACARANGA TANARIUS (L.) Muell.-Arg.

*Hexagona thwaitesii* Berk., dead twig.

MALLOTUS sp.

*Favolus philippinensis* Berk., dead branches.
*Lenzites palisoti* Fr., dead branches.
*Marasmius pilopus* Kalchbr., dead branches.

MANGIFERA CAESIA Jack.

*Coriolus hirsutus* (Fr.) Quel., dead branches.

MANGIFERA INDICA L.

*Auricularia polytricha* (Mont.) Sacc., dead branches.
*Hexagona thwaitesii* Berk., dead branches.
*Lenzites palisoti* Fr., dead branches.
*Microporus sanguineus* (Lév.) Pat., dead branches.
*Polyporus rugulosus* Lév., dead branches.
*Schizophyllum commune* Fr., dead branches.

MELIACEAE indet.

*Auricularia tenuis* Lév., dead branches.

MEMECYLON sp.

*Lycoperdon roseum* Zoll., dead stem.

MORUS ALBA L.

*Microporus xanthopus* (Fr.) Pat., dead branches.

MUSA SAPIENTUM L.
  *Lenzites tenuis* Berk., partly dead leaf.
  *Schizophyllum commune* Fr., dead leaf sheath.
PARASHOREA PLICATA Brandis.
  *Coriolus hirsutus* (Fr.) Quel., dead branches.
PARINARIUM sp.
  *Auricularia tenuis* Lév., dead branches.
PARKIA JAVANICA (Lam.) Merr. (*P. roxburghii* G. Don).
  *Auricularia polytricha* (Mont.) Sacc., bark of living tree.
  *Coriolus hirsutus* (Fr.) Quel., dead branches.
  *Hexagona thwaitesii* Berk. var. *retropicta* Bres., dead wood cuttings.
  *Lenzites palisoti* Fr., dead bark.
  *Trametes badia* Berk., dead trunk.
PREMNA ODORATA Blanco.
  *Auricularia mesenterica* (Dicks.) Fr., dead branches.
PROSOPIS VIDALIANA Naves.
  *Lenzites applanata* Fr., dead branches.
  *Schizophyllum commune* Fr., bark.
PSIDIUM GUAJAVA L.
  *Auricularia tenuis* Lév., dead branches.
  *Cyclomyces cichoriaceus* (Berk.) Pat., dead branches.
  *Microporus xanthopus* (Fr.) Pat., dead branches.
PTEROCARPUS sp.
  *Auricularia tenuis* Lév., dead branches.
PTEROCYMBIUM TINCTORIUM Merr.
  *Trametes persoonii* Mont., dead branches.
QUERCUS sp.
  *Cyclomyces tabacinus* (Mont.) Pat., dead branches.
  *Microporus xanthopus* (Fr.) Pat., dead branches.
SACCHARUM OFFICINARUM L.
  *Schizophyllum commune* Fr., dead stems.
SAPIUM MERRILLIANUM Pax et K. Hoffm.
  *Schizophyllum commune* Fr., dead branches.
SCHIZOSTACHYUM sp.
  *Schizophyllum commune* Fr., dead stem.
SIPHONODON CELASTRINEUS Griff.
  *Heterochaete tenuicula* (Lév.) Pat., dead branches.
TAMARINDUS INDICA L.
  *Schizophyllum commune* Fr., dead branches.
TERMINALIA COMINTANA Merr.
  *Trametes flava* (Jungh.) Pat., dead branches.
THEOBROMA CACAO L.
  *Auricularia mesenterica* (Dicks.) Fr., dead branches.
  *Polyporus rugulosus* Lév., dead branches.
TREMA sp.
  *Microporus affinis* (Nees) Pat., dead branches.
ZEA MAYS L.
  *Schizophyllum commune* Fr., dead stem.

# REVIEW

**A Handbook** | **of** | **Colloid-Chemistry** | **The recognition of colloids, the** | **theory of colloids, and their** | **general physico-chemi-** | **cal properties** | **by** | **Dr. Wolfgang Ostwald** | **Privatdozent in the University of Leipzig** | **second English edition** | **translated from the third German edition** | **by** | **Dr. Martin H. Fischer** | **professor of physiology in the University of Cincinnati** | **with numerous notes added** | **by** | **Emil Hatschek** | **Cass Institute, London** | **with 63 illustrations** | **Philadelphia** | **P. Blakiston's Son & Co.** | **1012 Walnut Street. Cloth, pp. i–xvi + 1–284, $3.50 net.**

Due principally to the rapidly increasing realization of the importance of colloid chemistry in various fields, especially in the practical applications of chemical science, the scarcity of textbooks on this subject has been felt. This new English edition of Wolfgang Ostwald's standard work will undoubtedly meet a ready reception. While not so much as might be wished has been added since 1912 (a thorough revision being impossible on account of the war), the results of some recent work, particularly of Hatschek's own researches on the physical properties of colloids, have been included.

A brief introduction includes the methods for recognition of colloids, their classification into suspensions and emulsoids, and the determination of their electric charge. Part I is a presentation of the theory of colloids, and includes chapters on their constitution, general properties, and energy relations. The present conception of colloid chemistry as a science dealing with surface-energy relations of a condition (the colloid state) which is very common, and in which any substance may be, is contrasted with the original view that the subject dealt only with a few glue-like substances. Part II takes up in detail the physical properties of colloids, such as vapor tension, viscosity, Brownian movement, and diffusibility.

The book is well suited for a text or a reference book for those whose work is related to the subject of colloids.

G. A. P.

THE PHILIPPINE

# JOURNAL OF SCIENCE

VOL. XV DECEMBER, 1919 NO. 6

# CAMPBELLOSPHAERA, A NEW GENUS OF THE VOLVOCACEAE

By WALTER R. SHAW

*Of the Department of Botany, College of Liberal Arts, University of the Philippines, Manila*

TWO PLATES AND ONE TEXT FIGURE

Mixed with several other species of Volvocaceae in living material collected at Pasig in July, 1914, there was a globular plant resembling in many respects *Volvox carteri* Stein. I regarded it as representing a new genus, and under the specific name *carteri* there accumulated in my notebook, in the course of months, a mass of data consisting largely of measurements and cell counts supposed to be descriptive of various stages in the life history of the plant. In November, 1916, when a written account of the new genus was nearly completed from the notes, a night session with a living specimen supposed to belong to the species revealed a difference in behavior inconsistent with the most distinctive character of the genus, thus making it evident that my description was a composite, embracing species of two genera. Consequently it has been my task to disentangle the descriptions of these species.

The plant which is the subject of this paper has globular, biciliate protoplasts with no protoplasmic connections. It has gonidia which are differentiated from the somatogenic cells at an early stage in the development of the embryo, and they become so large, before dividing in their turn, that the species may be called *megalogonidiate*. But the distinctive character of the genus is a migration of the gonidia from the outside to the inside of the embryo. In the bowl stage of the embryo they

are on the outside. They pass through the mouth of the bowl (the phialopore) just before closure occurs and form at first a close cluster within the embryo. Then, as the closed body slowly expands, the gonidia migrate forward from the region of the phialopore to take positions distributed within and near the wall of the coenobial cavity. For the genus of which the migratory habit of the gonidia is one of the distinctive characters I now propose the name **Campbellosphaera**, dedicating it to Douglas Houghton Campbell, whose life has been devoted to research on the life histories of plants as a basis for natural classification.

In the material from which the type specimen has been selected the asexual specimens are more or less ellipsoidal and the gonidial numbers vary from eight downward. The gonidia in each coenobium usually vary in size and are largest near the posterior pole and smallest farthest from that pole. As a rule the larger gonidia segment first and the successively smaller ones later, inversely in the order of their size. In other large-gonidiate species of this family when some gonidia are regularly unlike the others it is the posterior pair or quartette that are the smaller and segment last. As a mark of distinction from such, this species will be described under the name **C. obversa** gen. et sp. nov., the specific name having reference to the reversed arrangement of the gonidia as compared with other types of Volvocaceae.

Associated with the reversed arrangement of the gonidia, this species presents another character which may well be an additional distinguishing character of the genus. I have observed that the daughters nearer the posterior pole mature earlier and are born earlier than the others, and that all the daughters are born through one opening formed in the posterior pole. According to my observations on closely related genera, in all of them each daughter is born through a separate opening in the wall of the mother coenobium.

In 1896 Meyer, in Germany, described a species under the name *Volvox tertius*. It is nearer to the genus about to be described than to either of the older species of *Volvox*. Unfortunately Meyer gave no figures to show the general aspect of the coenobia, and it is impossible from his description and table of combinations of progeny to form, at this time, a conclusive opinion as to the proper disposal of his species. The form of the somatic cells and their membranes as shown in Meyer's text figures 5 to 7 is remarkably like that of the cells in the anterior part of the coenobium of *C. obversa* and different from

that of other Volvocaceae. But this resemblance may be more apparent than real.

## DESCRIPTION OF THE TYPE SPECIMEN

For the type specimen of *Campbellosphaera obversa* the one shown in Plate I, figs. 1 and 2, has been selected. Of twenty-three photographs of this species available at the time of writing this one best exhibits the characters of the genus and species. It is an asexual coenobium containing four embryos and three gonidia. The specimen was fixed with others from the same source in a chrom-acetic acid solution, washed, passed through gradually concentrated glycerin into alcohol, stained in succession with alcoholic Bismarck brown and alcoholic nigrosin, and mounted with a multitude of others in Venetian turpentine.

The material was collected from a pond in Pasay, indicated in my notes by the letter J, September 22, 1915, fixed at 11.30 in the morning on the following day, and stained and mounted during the ensuing season. The specimen was photographed with a magnification of 100 diameters on May 18, 1916 (the negative was accidentally destroyed after the making of two prints), and photographed again with a magnification of 200 diameters on the 23d of the same month. The two photographs show the specimen in the same position but with different levels in focus. Three weeks later, June 15, 1916, the specimen was examined for the purpose of taking descriptive notes and found to be flattened into a discoid form and turned up on edge. Three years later, June 7, 1919, the specimen was found to be almost completely overturned from its position at the time of making the photographs. All it lacks of being completely overturned is that the posterior pole is about 45 microns higher than the anterior pole. The present aspect of the specimen is so nearly an exact reversal of the photographs as to arouse a suspicion that the photographs had been taken on reversed plates. The facts that the two photographs taken on different days agree, and that the specimen was seen on edge, makes it clear that the revolution really occurred.

The coenobium appears to have been somewhat ovoid in form and measured at the time of photographing about 225 by 275 $\mu$. Three years later it measured about 200 $\mu$ wide by 235 $\mu$ long. The shrinkage thus shown to accompany the hardening of the Venetian turpentine seems to have been confined mostly to the cell membranes of the coenobium.

The protoplasts of the vegetative or somatic cells are round

and about 5 $\mu$ in diameter. They lack protoplasmic connections with their neighbors. They number about 2,830. The distance between neighboring protoplasts is about equal to the diameters of the protoplasts. In surface view a rather thick middle lamella, more deeply stained with Bismarck brown, is visible. In profile view the walls of all the somatic cells are seen to be rounded on the outer side, making the surface of the coenobium uneven. The inner membranes do not show plainly.

The specimen contains three gonidia, and four embryos which were formed from gonidia. Two embryos in the posterior part of the coenobium are in the same stage of development, and two embryos about in the equatorial plane are nearly in the same less-advanced stage of development. The three gonidia lie just in advance of the equatorial plane and are all mature and nearly ready for segmentation. They measure in the photograph 47 and 52 $\mu$ wide and are slightly flattened. Measurement of the same gonidia in the preparation on June 9, 1919, gave the same figures. Thus the gonidia show practically no shrinkage in three years while the membranes shrank from 11 to 18 per cent in dimensions during that time. The slight flatness of the gonidia is taken to be the first indication of approaching segmentation. The gonidia are highly vacuolate, with a centrally suspended nucleus containing a well-marked nucleolus. The membranes about each gonidium and about each embryo fit rather closely. The equatorial embryos have reached the bowl stage. Each bears eight gonidia on the edge of the bowl. The size of these gonidia indicates that they were differentiated and ceased to divide at about the 64-celled stage of the embryo. The bowl has a somewhat dentate edge with the gonidia in the points of the teeth. The somatic cells are very small, about 1 or 2 $\mu$ thick and 4 $\mu$ long, and are numerous, about equal in number to the somatic cells of the parent coenobium in the embryo next to the single gonidium, somewhat larger and about half as numerous in the embryo adjoining the pair of gonidia. This appears to indicate that this embryo is at a stage just preceding the last division of the somatic cells. Some marginal cells of the bowl, between the daughter gonidia, seem to be about twice as thick as the other somatogenic cells. This is suggestive of marginal growth of the bowl. The posterior embryos have reached the bullet stage. Their gonidia have entered by the phialopore and the latter has closed. The gonidia are packed too closely in the posterior part of the embryo to be counted.

Close to the posterior pole of the specimen are two half-grown specimens of an endophytic alga, of which one shows plainly in the photograph (Plate I, fig. 1). More mature specimens of *Campbellosphaera* on the same slide bear an abundance of these endophytes in many stages of development.

## OBSERVATIONS ON LIVING SPECIMENS

The earliest record in my notes pertaining to this genus relate to observations on living material collected at Pasig on July 30, 1914. Being mixed with larger species it was designated in the notes as "the smaller, spheroidal species of Volvox." The notes under the above date are as follow:

Collections of this morning show the smaller species with asexual reproduction. Very large gonidia radially vacuolate. Nearly closed daughter spheres with four and eight large cells, probably gonidia, which appear to be [derived from] undivided marginal cells of the saucer or cup stage. [These] migrated inward and became distributed in the * * * sphere. No protoplasmic connections in mother sphere. Cells of daughter very elongate and compactly arranged. External wall of cells of mother sphere very strongly convex on the outer side. Cells of the anterior pole larger and farther apart and with much larger stigmata.

Measurements of three living specimens were recorded under the same date:

*Specimen 1.*—Coenobium, 430 μ wide by 480 μ long. Somatic cells, spheroidal, 7 μ in anterior, middle, and posterior parts of coenobium. Intercellular distances, 8 to 12 μ, mostly about 10 μ. Cells in an area 180 μ square, 180. Estimated number of cells in coenobium, 3,470. Gonidia spheroidal; 82 by 85 μ, 80 by 81 μ, 86 by 88 μ, 88 by 90 μ, 89 by 94 μ. Daughters, 2; (1) 77 by 100 μ, with four gonidia about 25 μ, forming a close group in one end; space about the daughter 90 by 106 μ; (2) 77 by 100 μ, with four gonidia about 25 μ each also forming a close group in the blunt end; space about the daughter, 115 by 130 μ. Daughters rotating on polar axis.

*Specimen 2.*—410 by 460 μ. Cells, about 7 μ (in equatorial region somewhat less). Intercellular distances, about 8 to 10 μ. Counted twenty-six cells in an area 75 μ square. Estimate of number of somatic cells, 2,635. Gonidia measured 42 μ, 52 μ, 64 μ, 64 μ, 64 μ, 72 μ, 57 by 74 μ (about to divide). Daughter, 80 μ collapsed, with eight gonidia about 18 μ in diameter.

*Specimen 3.*—410 by 480 μ. Cells, about 7 μ. Intercellular space, 8 to 10 μ. Cells counted in 75 by 75 μ space, 24. Estimate of somatic cells, 2,520. Gonidia; anterior circle, 50 by 60 μ, 54 by 60 μ, 46 by 48 μ, 54 by 56 μ; posterior circle, 72 μ, 72 μ, 62 by 70 μ, 58 by 66 μ.

A record of the movement of the gonidia from the close cluster in the back of the newly closed embryo to a more scattered distribution in the daughter coenobium was made on the same day. In two embryos, at about 11.30 in the morning, the gonidia were

observed closely packed together within the phialopore, and at about 1.30 in the afternoon these same gonidia had passed forward within their spheres and taken up positions apart from one another.

Measurements of a number of less-mature specimens were made on August 4, 1914, from living material collected at Pasig on that day, as follow:

*Specimen 4.*—325 by 400 μ. Somatic cells, 5 μ (anterior 5 plus). Cells in 8,100 square μ near equator, 50 to 52. Number of somatic cells, about 2,425. Gonidia, 6; 55, 45, 62, 64, 60, and 70 μ.

*Specimen 5.*—270 by 320 μ. Somatic cells, about 5 μ. Cells in 8,100 square μ near equator, 72. Number of somatic cells, about 2,280. Gonidia 6; 40, 42, 50, 57, 50, and 56 μ.

*Specimen 6.*—370 by 450 μ. Somatic cells near equator, about 5 μ. Cells in 8,100 square μ, 39. Number of somatic cells, about 2,370. Gonidia, 6; 50, 58, 65 by 73, 58 by 66, 64 by 80, and 64 by 75 μ; some about to divide.

*Specimen 7.*—255 by 300 μ. Somatic cells near equator, about 4.5 to 5 μ. Cells in 8,100 square μ, 84. Number of somatic cells, about 2,370. Gonidia 6; 36, 40, 43, 43, 46, and 56 μ.

*Specimen 8.*—380 by 460 μ. Contained about 27 oospores or oospheres evenly distributed in the posterior three-quarters of the coenobium. Oospheres, 28 to 30 μ in diameter.

*Specimen 9.*—Presented the anterior pole and measured 320 μ in diameter. The four cells about the anterior pole were observed to form a diamond with transverse diameter about equal to each of its four sides. The anterior pole may be identified by the radially symmetrical arrangement of the stigmata about it. Gonidia, 5; 55 to 60 μ; dividing or about to divide.

## STAGES AND FORMS IN COTYPE MATERIAL

The cotype material of this species consists of specimens mounted (1) on the same slide, (2) on other slides from the same batch of stained material, (3) on other lots of slides from the same fixation, (4) material from the same collection, (5) material from the same pond at near the same date, and (6) material taken from near neighboring ponds on the same and near dates. On the same slide with the type specimen are nine hundred eighteen other specimens which appear to be of the same species, and one specimen of a *Volvox* species. There are six other slides of the same lot. A sister lot of seven slides differs in having been stained only with Bismarck brown, the treatment with alcoholic nigrosin solution having been omitted. The following data descriptive of specimens 10 to 18, inclusive, are from the slide bearing the type specimen:

To show the maximum number of gonidia and embryos, namely, 8, and also to show the appearance of the embryos after

their gonidia have begun to separate, the specimen (No. 10) shown in Plate I, fig. 3 was photographed. It measured about 280 by 295 $\mu$, and an estimate of the number of somatic cells is 2,675. The figure shows the anterior pair of embryos youngest, in the bullet stage. About in the equatorial plane is an anomalous pair consisting of a gonidium in the background and a more advanced embryo in the foreground. In the posterior quarter of the coenobium the micrograph seems to show an anomalous quartet, of which the embryo at the right is clearly the most advanced in development of all in the coenobium. Partly behind it appears a bullet embryo, and at the left a smaller gonidium. The fourth member of the quartet must have been a foreign body behind the coenobium, for now it cannot even be found near the specimen. Since being photographed the specimen has separated from its neighbor, rotated so as to present the posterior pole, and shrunken to the extent of diminishing the transverse diameter from 290 $\mu$ to 214 $\mu$. The gonidia show no shrinkage, but give slightly larger measurements, which may be attributed to more careful adjustment of the microscope. They are about 50 and 56 $\mu$ in diameter.

The extent to which the daughters and their gonidia develop before birth is shown in Plate I, fig. 4. This specimen (No. 11) now lies in almost exactly the position in which it was photographed. But its dimensions have decreased from 315 by 380 $\mu$ to 295 by 355 $\mu$. The thickness of the specimen at the present time measures, with an allowance of 1.4 for the optical density of the Venetian turpentine, about 260 $\mu$, which indicates practically no flattening from cover pressure.[1] The somatic protoplasts of the mother measure about 5 $\mu$. The characteristic convexity of the outer side of the membrane of the somatic cells is clearly exhibited under the microscope, especially in the optical sections of the protrusions caused by the pressure of the daughters. The convexity is such that the plane of the base of the dome often intersects the protoplast below the middle; that is, more than half of the protoplast lies within the dome. The spacing of the cells is estimated to be now about 10.8 $\mu$. This, with 315 $\mu$ taken as the mean diameter for the coenobium, gives us 3,080 for an estimate of the number of cells. The gonidia of the daughter were counted by carefully focusing with a high-power objective. The daughters number 7; and the gonidia in five of them are 8; in one, 7; and in one, 6. In four of the

[1] The cover glass is supported by glass rodlets of the following thicknesses; 346, 347, 373, and 378 $\mu$.

daughters it could be easily seen that the posterior gonidia are larger than the others. The largest and the smallest gonidia in each daughter were measured and the range of diameters found to be from 18 to 38 $\mu$; the largest minimum, 28 $\mu$; and the smallest maximum, 29 $\mu$. This specimen contains a number of endophytic algae in various stages of development.

An arrangement of the gonidia in three symmetrical pairs is shown by Plate I, fig. 5, a photomicrograph of a coenobium containing a posterior pair of embryos and two pairs of gonidia. This specimen (No. 12) measured at the time of taking the photograph about 255 by 290 $\mu$. Its appearance after three years is so altered by shrinkage and rotation that several hours were lost in hunting for it. It was found to have rotated about a quarter turn to the right and to have shrunken to about 175 by 210 $\mu$. The somatic protoplasts are a little over 5 $\mu$ in diameter, but the thickness of the membrane between the protoplasts is reduced to about a micron, making the average cell diameter about 6 $\mu$. This gives 3,520 for the estimate of the number of cells. The gonidia still measure, as in the photograph, about 55 by 60 $\mu$. One of the anterior pair is slightly smaller than the others. The two embryos are nearly but not exactly at the same stage, the daughter gonidia being in the act of entering through the phialopore in one, and having accomplished the entry in the other.

The relative frequency of the different numbers of gonidia in the coenobia on the type slide was estimated by counting the gonidia, or the gonidia and the embryos, or the daughters, in coenobia which had not released any daughters. For this purpose a strip across the middle of the slide was passed in view until a hundred counts had been made. There were found:

| | |
|---|---|
| 1 | coenobium containing 3 gonidia or daughters. |
| 1 | coenobium containing 4 gonidia or daughters. |
| 2 | coenobia containing 5 gonidia or daughters. |
| 34 | coenobia containing 6 gonidia or daughters. |
| 32 | coenobia containing 7 gonidia or daughters. |
| 30 | coenobia containing 8 gonidia or daughters. |
| 100 | |

On this slide, though the nine hundred coenobia were all passed in view twice and many parts of the preparation were seen many times, no mother coenobium was observed to contain any but asexual daughters; that is, daughters containing gonidia.

There are six sexual coenobia on the type slide. One of these (specimen 13) is shown in Plate I, fig. 6. In the photograph it

measures about 250 by 300 $\mu$. In June, 1919, it measured 230 by 285 $\mu$. The somatic protoplasts are about 5 $\mu$ in diameter and the total cell width is about 10 $\mu$. The estimated number of somatic cells is 2,200. The general appearance of the somatic cells and their membranes resembles that of the asexual coenobia at about the time when the gonidia divide. At the present time the radial dimension of the somatic cells varies from about 20 $\mu$ between the oospores to about 10 $\mu$ over the spores, grading gradually from one size to the other. The protoplasts in all the cells lie close to the convex or rounded outer end of the somatic prisms. There are present twenty-three reproductive cells which are scattered throughout the coenobium just under the somatic layer except for a small vacant space about each pole and another on each side of the coenobium. Applying the simplest interpretation to them, I will call four dark ones, with thin walls and diameters of about 37 $\mu$, oogonia; and nineteen paler ones, with thick walls and diameters of about 42 $\mu$, oospores. The protoplasm of both these kinds of cells is much denser than that of the gonidia in any stage of the latter that has been observed. Vacuoles are practically absent and the nucleus is not evident. The thickened wall of the oospores fits loosely and in optical section is wavy from reticulate wrinkles. The spore wall seems to hinder the penetration of stains and other reagents. An oogonium and two oospores from this coenobium were photographed with a magnification of 400 diameters and they are shown in Plate I, fig. 7. I have closely inspected this specimen, and the six other specimens on the same slide, for vacancies in the pattern of somatic cells and protoplasts which might represent the sites, either of cells that became oogonia, or of cells that had formed antheridia. I found only one vacancy. It appears to be a somatic cell membrane of about one and a half times the usual diameter, containing in place of a protoplast a cavity of about one and a half times the diameter of the average protoplast. It lies beside (not directly over) one of the oospores on the upper face of the coenobium. I am unable to attach any particular significance to it. There is a number of endophytic algae present in the somatic layer. The layer is somewhat battered and broken, and one or more of the oospores seem to have been fixed when about to make their escape. Each of the neighboring coenobia in Plate I, fig. 6, contains seven gonidia.

A younger sexual coenobium (specimen 14) on the type slide is shown in Plate I, fig. 8. It contains twenty-nine reproductive

cells, of which twelve with diameters of about 29 μ are darker and thin walled, and sixteen with diameters of about 34 μ are lighter in color (they appear to have taken up some Bismarck brown but no nigrosin) and enveloped with walls which vary in thickness and in closeness of fit, the thicker ones fitting their protoplasts more loosely, and all having reticulations developed as ridges. One thin-walled reproductive cell on the far side of the coenobium is smaller, about 25 μ, and lighter colored than the others, and may possibly be an endophyte. The coenobium measured about 250 by 275 μ when it was photographed and now is 230 by 255 μ. The somatic protoplasts have diameters of about 4 to 5 μ and are in the outer rounded ends of their prismatic membranes. The average cell diameter is about 9.4 μ. The estimated number of somatic cells is 2,300. That this coenobium is younger than the one shown in Plate I, fig. 6, is evident, not only from the larger proportion of oogonia to oospores, but from the incomplete development of the oospore walls. The large number of relatively less-mature endophytic algae also marks this coenobium as younger than the other. The reproductive cells are absent about the anterior pole, and to a lesser extent about the posterior pole, though the latter point is more evident in the present position of the coenobium than in that which it occupied at the time when the photograph was taken. The radial dimensions of the somatic-cell membranes does not reach the size of those in the preceding specimen.

Notes on the four other specimens of sexual coenobia on the type slide, taken in June, 1919, follow:

*Specimen 15.*—Coenobium ovoid, 235 by 245 μ. Anterior end larger. Somatic prisms about 20 μ radial dimension about the anterior pole. Oogonia, 28; 39 μ, with central nucleus; a zone of dark bodies, possibly chromatophores, about one-fourth or one-fifth radius from the periphery and one-half or three-fifths radius from the center of the protoplast.

*Specimen 16.*—Coenobium, 210 by 270 μ. Somatic protoplasts, about 5 μ. Average cell diameter, about 10 μ. Estimate of somatic cells 1,920. Reproductive cells, 23. Oogonia, 16; 30 to 35 μ. Oospores, 7; protoplasts, about 32 μ, walls about 40 μ. Each oogonium has a central nucleus and dark bodies in the outer half of the radius. The oospores have a small central nucleus or nucleolus. Two have walls almost smooth. The protoplasts are eccentric. Three oogonia and one oospore appear more or less disorganized and are surrounded by fungus hyphae.

*Specimen 17.*—Coenobium, 260 by 295 μ. Cells, about 2,330. Reproductive cells, 25. Oogonia, 2; 32 and 35 μ. Oospores, 23; grading from dark to light, 19 being darker and 4 lighter, the latter nearer maturity. Ridges on spores high. Most spores with nucleus eccentric, twice as far from one side as from the opposite.

*Specimen 18.*—270 by 340 μ. Somatic plastids, about 5.3 μ. Somatic cells, about 11.9 μ; number, about 2,660. Oogonia, none. Oospores, 17: outer wall, 44 μ; protoplast, 37 μ, eccentric.

A sexual coenobium (specimen 19) containing both oogonia and antheridia is shown on Plate I, fig. 9, a micrograph taken June 18, 1919, from another slide (No. 4) of the same lot as the type slide (No. 2). It measures about 180 by 195 μ. The diameter of the somatic protoplasts is about 5 μ, and of the cells including the membranes 7.1 μ. The estimate of the number of somatic cells is 2,460. There are present in the coenobium 25 oogonia and 3 antheridia, together with two masses of matter which may represent disseminating antheridia. The oogonia are about 24 μ in diameter. The antheridia are platelets 33, 34, and 36 μ wide, and about 6 μ thick. They are more or less convex on what I take to be the ciliated side. All three present edge views. One is on the right side near the anterior pole, one on the right side near the equator, and one on the left side midway between the equator and the posterior pole. The count of cells in the median optical section of a platelet is about 14, which number corresponds aproximately to the diameter of a platelet containing 128 spermatozoids. The distribution of the reproductive organs in the coenobium is as follows:

| | | | |
|---|---|---|---|
| Anterior quarter | 1 oogonium. | 1 antheridium. | |
| Second quarter | 11 oogonia. | 0 antheridium. | |
| Third quarter | 7 oogonia. | 2 antheridia. | |
| Posterior quarter | 6 oogonia. | 0 antheridium. | |
| Total | 25 oogonia. | 3 antheridia | plus 2 ? |

Two other sexual coenobia on the same slide have the following characters:

*Specimen 20.*—215 by 220 μ. Somatic protoplasts, 5 μ; cells, 8.5 μ; number, 2,360. Oogonia, 29; about 28.5 μ; absent in anterior quarter, and leaving open spaces on the near and far sides of the coenobium.

*Specimen 21.*—200 by 210 μ. Somatic cells, about 7.1 μ; number, about 2,960. Oogonia, 11; 25 μ; oospores, 8; 30 μ; smaller reproductive cells, 3; 14 to 18 μ; remains of sperm masses (?), 3. Reproductive cells absent from the anterior third of the coenobium.

An asexual mother coenobium (specimen 22) containing both asexual and sexual daughters is shown on Plate II, fig. 10, a micrograph taken on June 18, 1919, from a third slide (No. 6) of the same lot. Specimens such as this serve to establish the fact that asexual and sexual coenobia, such as have been described in the foregoing paragraphs, occur in the same species. This evidence is not superfluous, for on the slides of this lot

there is a small percentage of specimens of three other species of Volvocaceae, including some of *Volvox africanus* West, a species of similar dimensions. The mother coenobium of specimen 22 (Plate II, fig. 10) measures 230 by 270 μ, and has somatic protoplasts of about 5 μ diameter and cell diameters of about 9 μ, the number of cells being about 2,640. The asexual daughter measures 95 by 105 μ and contains seven gonidia. Of these the smallest is 16 by 18 μ, and the largest, 43 by 45 μ. There are six sexual daughters. Of these the smaller near one (in the left side of the picture just above the middle) contains twenty-seven reproductive cells, of which eight are small and medium-sized, 11 to 12 μ, and nineteen are large, about 17 μ. The larger near daughter (in the lower side of the figure) contains about twenty-nine reproductive cells of 15 to 18 μ. The other daughter with reproductive cells in plain view (the lower one on the left side of the photograph) contains about thirty-one reproductive cells of 15 and 18 μ, mostly of the larger size. The three other sexual daughters have about the same number of reproductive cells, and all of the sexual daughters are elongated and free from reproductive cells in one end. A number of endophytic algae are prominent in the walls of the mother coenobium.

Several other examples of mother coenobia, containing mixed broods of progeny differing in no significant particular from the one just described were found on the slides of the lot under consideration.

A sexual coenobium with a smaller number of reproductive cells occurs as a daughter in the mother coenobium shown in Plate II, fig. 11. This specimen (No. 23) is on one slide (No. 1) of a lot prepared from the same material as the type slide, but with the omission of the nigrosin stain. The mother coenobium measured, when the micrograph was taken in June, 1919, 170 by 210 μ. The somatic protoplasts were then about 5 μ in diameter and the average cell width about 7.1 μ. The estimated number of cells is 2,420. The mother contains one gonidium, 52 by 53 μ, four asexual embryos, and one sexual embryo. The most advanced asexual embryo is not much beyond the bullet stage. This embryo is elongate, 57 by 75 μ, almost pointed at the anterior end and blunt at the opposite end. It contains eight gonidia of about 18 μ diameter. Four of these are closely grouped against the posterior wall of the coenobium, three lie almost a gonidial cell diameter in advance of the posterior quartet, and one is almost two diameters ahead of the quartet. Beneath this embryo there lies one in the typical bullet stage.

side view, with the gonidia too closely packed to be counted. The two other asexual embryos are still less advanced, but with the entry of the gonidia accomplished. The sexual embryo, the presence of which is the reason for the description of its sisters and mother, is nearer the posterior pole and more advanced in development than any of its sisters. It retains the bullet form, with a sharper and blunter end, and measures 60 by 82 $\mu$. The average cell diameter is about 3.6 $\mu$; and the estimated number of cells is 1,250. The reproductive cells are sixteen in number and about 12 and 14 $\mu$ in diameter. They are arranged in four alternating and intermeshing quartets, distributed in about three-fourths of the length of the coenobial cavity, the anterior quartet being more separated from its neighbors than are the others.

Another sexual coenobium (specimen 24) with a small number of reproductive cells is shown in Plate II, fig. 12. It is on another slide (No. 12) of the same lot as the type slide. It measures 160 by 170 $\mu$. The somatic protoplasts are about 5 $\mu$ wide, and the somatic cells about 8.3. The number of cells is estimated at 1,400. The reproductive cells are fifteen in number. Thirteen of them are oogonia of about 28 $\mu$, and two, near the posterior pole, are oospores of about 32 $\mu$, with the walls as yet only slightly developed. There is an absence of reproductive cells in the anterior quarter of the coenobium.

Material containing a larger proportion of sexual coenobia was collected in a shallower neighboring pond, F, within a stone's throw of pond J. A lot collected about 4 o'clock in the afternoon, September 22, 1915, was fixed in the laboratory at 8 in the morning on the following day. A batch of these, stained with Bismarck brown, saturated with Venetian turpentine, was mounted in abundance on four slides and sparingly on three others. In June, 1919, I looked at all of the specimens on slide 1 of this lot, and at about 4 per cent of the area of each of the other mounts. These slides show not only a greater abundance of sexual coenobia of *Campbellosphaera obversa*, but also a larger proportion of other Volvocaceae, including *Volvox africanus* West, the latter being represented by sexual as well as by asexual specimens. The asexual specimens of these two species are readily distinguishable, but the free female coenobia of *V. africanus* are very similar to the sexual coenobia of *C. obversa* in these preparations.

In this material many asexual coenobia were found containing asexual and sexual daughters in different numerical combina-

tions. In many of the sexual daughters sperm platelets are present in the unborn daughters. In no case were antheridial coenobia seen in the mother coenobia of this species, though they are common in the *V. africanus* coenobia mixed with them. The staining of this material does not fit it for making photomicrographs with distinct detail. For this reason I present without illustration the descriptive data pertaining to two selected specimens:

*Specimen 25.*—Mother coenobium, 250 by 275 μ. Estimate of somatic cells, 2,850. Daughters, 7; three asexual in a forward group and four sexual in two pairs in the posterior half of the mother. Each asexual daughter contains eight gonidia, of which the diameters range from 18 to 21 μ, 18 to 21 μ, and 19 to 25 μ. The youngest asexual daughter measures 70 by 75 μ, and the eldest, 90 by 95 μ. The latter has an average somatic cell width of 3.7 μ and an estimated number of somatic cells of 2,190. One of the sexual daughters measures 95 by 110 μ and has an average somatic cell width of 7.5 μ and an estimated number of somatic cells of 645. It contains eight oogonia of about 19 μ and eight antheridia. The latter are sperm platelets more or less dished. Another sexual daughter contains twelve oogonia and four antheridia, one of the latter being hemispherically cup-shaped. A measurement of 23 μ across the mouth of the cup, with about 1.8 μ for the spacing of the sperms, gives an estimate of more than two hundred fifty-six for the number of sperms in this antheridium. The next daughter contains sixteen oogonia and no antheridia, and the last one fifteen oogonia and one antheridium.

A number of gonidia, or gonidial products, greater than eight was noticed in only one specimen that could be certainly identified as belonging to this species.[2] It is on the same slide as the preceding. The generic characters presented by the embryos render its identity unmistakable. A description of it follows:

*Specimen 26.*—Coenobium, 210 by 220 μ. Somatic cell width, 8 μ. Number of cells, 2,570. Contents, 4 gonidia and 5 embryos. The gonidia lie near the coenobial equator, in advance of it, and measure 44, 50, 50, and 54 μ. The embryos are grouped in the hinder part of the mother. Four are in the closing bowl stage and one, the hindmost, is in the bullet stage.

The extent of the cell membranes around the gonidia and the embryos produced from them is not easily discernible, even in much of the material which has been stained with Bismarck brown. Although the inner limit usually becomes visible as

[2] The only other specimen containing more than eight gonidia on this slide is one with dimensions 190 by 205 μ; average cell width, 4.2 μ; number of cells, 7,800; and nine gonidia, all of which measure about 40 μ, except one near the posterior pole, which is 36 μ. This is probably a specimen of *Volvox carteri* Stein (*V. weismannia* Powers).

soon as the membrane ceases to conform with the segmentation products of the protoplast, the outer limit is visible only in cases of more or less deeply stained material. Examples of such are found on slides bearing material stained with Bismarck brown alone (Nos. 1 and 3). In the shrunken, Venetian turpentine preparations each gonidium is surrounded by a membrane which has almost no thickness on the outer side, but reaches to the center of the coenobium on the inner side, grading from one side to the other in such a way that the cavity of the coenobium is filled with the substance of these walls, except for very small interstitial spaces where three of the walls meet, and a large space in the anterior quarter of the coenobium. The very thin outer part of the gonidium wall has an extent of about a fourth or fifth of the circumference of the gonidium, and a corresponding superficial area of the gonidial protoplast is in close relationship with neighboring somatic cells. A large proportion of the shrinkage that occurs in the Venetian turpentine specimens takes place in the gelatinous matrix, if there be such, which fills the coenobial cavity.

The natural form of the membranes of the gonidial cells is best shown by specimens near the margins of the cover glasses of the type slide and others of the same and sister lots of Venetian turpentine preparations. The marginal and submarginal specimens on these slides are swollen instead of shrunken like those which make up the bulk of the preparation. This is true under about the marginal millimeter of the 24 millimeter square covers. The specimens here are beautifully plump. In fact many of them seem to be excessively turgid. The swelling involves only the cell membranes and not the protoplasts. It is most marked at the edge of the cover and in a space the greater part of a millimeter in width. Then, in a narrower zone, the specimens grade off from terete to shrunken. The marginal specimens are also faded. The Bismarck brown is here more rapidly and completely faded than the nigrosin stain, in both the single- and double-stained material. The most beautiful of the specimens are the coenobia in which full expansion of the cell walls has been accompanied by a certain degree of bleaching. In some of these, careful focusing reveals the gonidial membranes. In a coenobium with well-developed gonidia it can be seen that over an area on the outer side of the gonidium its membrane is very thin, as noted in the shrunken specimens, and that on the inner side it is very thick—thicker than in the shrunken specimens—so thick as almost to fill the central cavity of the coenobium and

to form planes of contact with the walls of opposite and neighboring gonidia. The thickening of the inner wall of the gonidium, sufficient for contact with the walls of the neighbors, extends outward to about the equatorial plane of the gonidial protoplast. From this region outward the walls separate and rapidly shade off in thickness, leaving an intercellular space between the gonidial walls and the walls of the somatic layer. The anterior walls of the anterior quartet of gonidia round out into the anterior intercellular space of the coenobium.

The terete condition of the coenobia under the margins of the cover glasses seems to be due to the absorption of atmospheric moisture during the storage of the preparations. The first water absorbed seems to be taken up by the cell membranes, particularly by the intralamellar substance of the somatic and gonidial cell walls, and by the substance in the intercellular coenobial cavity. After sufficient water has been absorbed for the complete expansion of the cell walls, additional water absorbed seems to be taken up by the protoplasm and by salts in the vacuoles, rendering the specimens unsightly.

The form and extent of the membranes of the sexual reproductive cells I have not been able to determine.

The details of the structure of the somatic protoplasts as they occur in the living and the fixed material are yet to be studied, and will not be taken up here.

The full history of the segmentation of the gonidia and the metamorphosis of the embryos will likewise be left for future study. The material on the type slide was purposely fixed at an hour when the characteristic stages of the embryos were present in abundance, with the result that stages of segmentation of the gonidia are lacking in this batch of material.

The most distinctly peculiar features of the ontogeny of this species appear in Plate II, figs. 13 and 15. These are both from slide 1 of the pond F material. Fig. 13 shows a specimen (No. 27) in which the youngest of seven embryos, in the left upper quarter, is in the bowl stage with the gonidia perched on the rim of the bowl. The older embryos are in the bullet stage, the four in the center and the right upper quarter presenting side views, and the two lower ones presenting almost rear polar views. In all of these bullet embryos, except the nearer one showing a side view, the gonidia are closely packed, and in the exceptional case they have begun to separate.

The bullet embryos are shown on a larger scale in Plate II, fig. 15, a view of a specimen (28) containing six embryos and one

gonidium. These embryos are all in the same stage. The same specimen is shown in fig. 16 on a smaller scale for comparison with fig. 17.

The separation of the gonidia in the daughters is shown in Plate II, fig. 17, a mother coenobium (specimen 29) containing six daughters and one gonidium. In all of the daughters the gonidia have become separated, and they can be counted by focusing the microscope. The number in each case is eight. In this stage the species is not easily distinguishable from *Volvox carteri* Stein.

The variation and graduation in size of the gonidia in the same coenobium, and the consequent gradation in advancement of sister embryos, may be practically lacking, as shown by figs. 15 and 17 of Plate II. On the other hand, a multitude of specimens can be found with a gradation as pronounced, and an arrangement as symmetrical, as is shown in Plate II, fig. 14, which shows an asexual specimen (No. 30), containing six gonidia arranged in three alternating pairs. This is from slide 1 of the pond J material.

The number of somatic cells estimated to occur in the specimens described, together with the number of reproductive cells counted in each case, are given in Table I.

TABLE I.—*Number of cells in Campbellosphaera obversa.*

| Asexual coenobia. | | | Sexual coenobia. | | |
|---|---|---|---|---|---|
| Specimen No. | Somatic cells. | Reproductive cells. | Specimen No. | Somatic cells. | Reproductive cells. |
| 12 | 3,520 | 6 | 21 | 2,960 | 22 |
| 1 | 3,470 | 7 | 18 | 2,660 | 17 |
| 11 | 3,080 | 7 | 19 | 8,460 | 28 |
| 25 | 2,850 | 7 | 20 | 2,360 | 29 |
| Type | 2,830 | 7 | 17 | 2,330 | 23 |
| 10 | 2,675 | 7 | 14 | 2,300 | 28 |
| 22 | 2,640 | 7 | 13 | 2,200 | 23 |
| 2 | 2,635 | 8 | 16 | 1,920 | 23 |
| 26 | 2,570 | 9 | | | |
| 3 | 2,520 | 8 | | | |
| 4 | 2,425 | 6 | | | |
| 23 | 2,420 | 6 | 24 | 1,400 | 16 |
| 6 | 2,370 | 6 | 23[a] Daughter | 1,250 | 16 |
| 7 | 2,370 | 6 | | | |
| 5 | 2,280 | 6 | | | |
| 25[a] Daughter | 2,190 | 8 | 25[b] Daughter | 645 | 16 |

The foregoing descriptions form the basis for the following:

### DIAGNOSIS OF GENUS AND SPECIES

#### CAMPBELLOSPHAERA genus novum

(*Volvocaceae, Volvoceae*)

Body a spherical or spheroidal coenobium of biciliate cells which contain chloroplasts. The cells appear to lie in the periphery of a gelatinous matrix surrounded by a hyaline envelope through which the cilia extend. Somatic protoplasts globose or ovoid, each enclosed in a thick gelatinous membrane which is prismatic in form with truncate interior end and more or less rounded exterior end. No protoplasmic filaments connecting the protoplasts. Asexual reproduction by gonidia, differentiated in early embryonic stages, which migrate from without into the interior of the embryo through the phialopore before closure. The gonidia are distributed and held in place by their thickened gelatinous walls. They develop to relatively large size before segmentation. Sexual reproduction by oospores which are more numerous and smaller than the gonidia, and are usually formed in the same coenobia with antheridia. Antheridia less numerous than the oogonia, in the form of platelets. Spermatozoids elongate, probably with terminal cilia.

#### CAMPBELLOSPHAERA OBVERSA sp. nov.

Coenobium spheroidal or more or less elongate; dimensions commonly less than 500 $\mu$. Number of somatic cells mostly between 2,000 and 3,000; protoplasts globose, about 5 $\mu$ in diameter; cell membranes very convex on the outer side. Gonidia, usually 8, 7, or 6, sometimes fewer, seldom more, arranged in quartets, or pairs, or a quartet and one or two pairs, in graded sizes arranged symmetrically with respect to the polar axis of the coenobium; those of the posterior pair or quartet the largest and segmenting first, those of the anterior pair or quartet smallest and segmenting last. Gonidia, 15 to 18 $\mu$ in diameter when differentiated, attaining diameters of 50 to 90 $\mu$ before dividing. Daughter coenobia developing their gonidia to large size before birth. All daughters born through one hole formed by loss of somatic cells in a circular area about the posterior pole. Asexual and sexual daughters formed in the same mother coenobia. Sexual coenobia monoecious. Gametangia more numerous and smaller than the gonidia, largest number, about 30; diameters, about 12 to 14 $\mu$ when first differentiated, becoming about 29 to 37 $\mu$ in diameter; the smaller becoming antheridial platelets of 128 sperms, the larger more numerous and becoming oogonia.

Outer wall of oospore reticulately wrinkled or ridged, diameter, about 34 to 42 $\mu$. Spermatozoids, about 6 $\mu$ long.

*Habitat.*—Fresh-water ponds, near Manila, Philippine Islands.

COMPARISON WITH PREVIOUSLY DESCRIBED SPECIES

The earliest described *Volvox* with megalogonidia similar to those of *Campbellosphaera* is *Volvox carteri* Stein ('78), which was described by Carter from Bombay, India, in 1859, under the name *Volvox globator.* Carter's description presented the large gonidia, one of which is shown in his fig. 4. That these gonidia must be differentiated early in the ontogeny is evident from the size which they reach before birth as shown in his fig. 1. Points of difference from *Campbellosphaera* appear in this figure; namely, the globose form of the coenobia, and the practically uniform size of the gonidia in each daughter. This uniformity is further shown in his fig. 3, in which the gonidia have reached the maximum size before segmentation. Carter represented his species as having somatic cells with globose or ovoid protoplasts, in which respect it is like our new genus.

A variety of *Volvox carteri* was described by Powers ('08), from Missouri, under the name *Volvox weismannia.* Powers failed to perceive that what Carter, in referring to his fig. 4, called a "daughter" was in reality a gonidium and identical with one of the reproductive cells which Powers called "primary sex cells" and "ova." Powers did, however, clearly recognize and emphasize the fact that these reproductive cells are differentiated at an early stage in the development of the embryo. The semi-diagrammatic nature of Carter's drawings masked the symmetry of the arrangement of the gonidia in the coenobia, which Powers noted as characteristic of his species. Powers supplied enough information on the embryos to show that the species lacks a migration of the gonidia such as is characteristic of *Campbellosphaera.* He showed clearly that his species also forms "dwarf male" coenobia, a point of difference from *C. obversa.* He overlooked the distinction between asexual and female coenobia, though he figured embryos of both kinds [Powers ('08), Plate 26, fig. 45 asexual, and fig. 47 female].

In my own collections, made in the neighborhood of Manila, on many of the eight hundred thirty-four slides of *Volvox* in my cabinets, and among the one hundred fifty photomicrographs of *Volvox* that I made in 1916, there is a multitude of forms and stages of *Volvox carteri*, which promises to afford material

for a more complete account of the species than has yet been published.

Another species with megalogonidia and other characters similar to those of *Campbellosphaera* was described by West ('10) from Albert Nyanza under the name *Volvox africanus.* This species also has the gonidia differentiated at an early embryonic stage. The original account of this species is sufficiently complete to mark it as entirely distinct from *Campbellosphaera,* though in form and size of the coenobia it approximates the characters of the latter.

Several varieties of *Volvox africanus* are abundant in my Philippine material, which should serve as a basis for a more complete account of this species also.[3]

A species of *Volvox* found by Meyer ('96) in Germany, and called by him *V. tertius,* resembles *Campbellosphaera* in having large gonidia, which are probably differentiated early, and in having round somatic protoplasts without protoplasmic connections. Meyer's text figure 7 would serve as well for a diagram of a radial section through the somatic cells of *Campbellosphaera obversa* if the outer peripheral membrane, or cuticle, *p*, were absent, leaving the intercellular spaces, *o*, continuous with the surrounding space. *Volvox tertius* appears to be more nearly related to *Campbellosphaera* than to the older species of *Volvox.* It is unquestionably distinct from both *V. globator* Ehrenberg and *V. aureus* Ehrenberg. Still there is lack of a sufficiently complete description to enable us satisfactorily to assign it to its place among its kindred.

Some specimens, collected and prepared by Doctor Migula, of Karlsruhe, were described and figured by Klein ('89B) under the name *V. aureus,* which I believe to have been an incorrect use of the name. Six of the eight coenobia figured (Plate 3, figs. 1 to 3 and 6 to 8) show daughters containing gonidia, gynogonidia, and androgonidia, all so large as to indicate plainly that the specimens belong to a megalogonidiate species. It is, therefore, questionable whether the cells that Klein called fertilized eggs ("kürzlich befruchtete Eier") were really such and

[3] At the present time, June, 1919, the manuscript is partially prepared of a paper describing at length *Volvox carteri* and *V. africanus* and proposing for them a new genus to be known as *Merrillosphaera.* The leading species of this genus will then be; *Merrillosphaera carteri* (Stein) Shaw (synonyms: *Volvox globator* Carter non Ehrenberg, *V. carteri* Stein, *V. weismannia* Powers) and *Merrillosphaera africana* (West) Shaw (synonym: *Volvox africanus* West).

not megalogonidia such as others have mistaken for eggs. It is even questionable whether the connecting filaments shown in Klein's fig. 7 ('89B, Plate 3) really belong there. The material is of a species more nearly akin to *V. tertius* and *V. carteri* than to *V. aureus*.

A more completely described species is another by Powers ('07 and '08), from Nebraska and other parts of North America, to which he gave the name *V. spermatosphaera*.[4] This species also has rounded somatic protoplasts without protoplasmic connections, and the number of the cells has a range like that of *Campbellosphaera*. But the dimensions of the coenobia run to much larger sizes, the cells being farther apart. The gonidia, or primary sex cells, are of considerable size in the daughters at the time of birth, though not so large as to indicate their differentiation at such an early period as is characteristic of *Campbellosphaera* and the kindred megalogonidiate Volvoceae. The species is characterized by having male coenobia of which all the cells become antheridia (sperm platelets), leaving no somatic cells.

In my Philippine material there is still another species, apparently most nearly related to *V. spermatosphaera*, awaiting its turn to be described.[5] It is like the foregoing species in many respects, except that the gonidia are smaller at birth, and the antheridia are relatively fewer and formed in the same coenobia as the oogonia.

A recent addition to the free-celled larger Volvoceae is one described by Powers ('07) from material obtained in Nebraska, and named by Shaw ('16) who proposed it as the type of a new genus under the name of *Besseyosphaera powersi*. This species is more like a *Pleodorina* Shaw ('94) than like a *Volvox*, the gonidia not being differentiated in the daughters until after birth of the coenobia in which they are formed. The life history of *Pleodorina californica* has been rounded out by Chatton ('11) from the study of material collected in France. A step farther down the scale is the species *P. illinoisensis* Kofoid ('98), the simplest of the Volvoceae which have differentiation of reproductive from somatic cells. The life history of this species has been given in detail by Merton ('08) from material obtained in Germany.

[4] Originally spelled "*spermatosphara*," and emended by West ('16).

[5] The manuscript of the description of this species is partially prepared and the species assigned to be the type of a proposed new genus under the name *Copelandosphaera dissipatrix* Shaw.

The earliest described and well-established European species of *Volvox*, *V. globator* Ehrenberg ('38) and *V. aureus* Ehrenberg ('38), were described at length by Cohn ('75), whose colored plate of *V. globator* has long been a classic for textbook and handbook illustration, and by Klein ('89A and '90), who made the largest contribution to the stock of pictures of *V. aureus* in various stages and phases. His figures include at least one, ('90) Plate 2, fig. 4, which is decidedly not of *V. aureus*, but of one of the megalogonidiate species. At about the same time Overton ('89) made a contribution to the knowledge of the life history of the then known European species of *Volvox*. More exact knowledge of the cell membranes of the somatic cells of the two European species was the result of the work of Meyer ('95 and '96) who incidentally gave us what information we have on his new species, *V. tertius*. His diagrammatic drawings of the cell membranes of *V. globator* and *V. aureus* are becoming classic by reproduction in handbooks. I never look at these drawings without feeling that it is improper to retain these two species in the same genus.

A species with a close affinity to *V. globator* was described by Powers ('08) from Nebraska under the name *V. perglobator*. The somatic protoplasts of this species are highly stellate and connected with their neighbors. The same is true of another species described by West ('10) from Rhodesia under the name *V. rousseleti*. In this one the cells are smaller and more numerous.

My own Philippine material[6] contains at least two species, both labeled with new names in my note books and in the albums containing their photomicrographs, which are more or less closely similar to *V. globator*, *V. perglobator*, and *V. rousseleti*.

In 1914 my collection of slides contained two excellent glycerin mounts of *Volvox aureus* (labeled *V. minor*) marked "4-16-96." The date indicates that the specimens were collected at Stanford University, California. They were under cover glasses sealed to the slides with Brunswick black which had cracked and become loosened. They had been fixed and stained with picro-nigrosin and the glycerin was slightly tinged with the picric acid. The staining had been very light. The specimens were mostly in beautiful condition after eighteen years under the covers, but the glycerin had partly escaped and was

[6] Some material collected in Borneo by Mary Strong Clemens contains a similar species.

still going. The appearance of the coenobia under the low powers, and the characters of the protoplasts, protoplasmic filaments and spores under the high powers, were so exactly like the excellent figures of Klein ('89A and '90) and of Overton ('89) as to engender in any one who studied the specimens with the literature a feeling that Volvoces must be about the same all over the world, and that both of the existing species have been well described. It was evident that the specimens would need remounting. Before demounting them, I took some notes and measurements—and fortunately, for the specimens after being remounted are not what they used to be.

The most recent advance in our knowledge of *Volvox* has come from the studies of Janet ('12 and '14) in France. In a long paper he gave a monographic account of the genus in which he incorporated and extended the membrane studies of Meyer, and he followed that with a preliminary paper in which he announced the discovery that the egg apparatus of *Volvox globator* is not a unicellular oogonium, but that it is multicellular and morphologically a dwarf coenobium. This fact will necessitate careful study of the corresponding parts of other species of *Volvox* and related genera.

There are two well-marked groups of the higher Volvoceae: (1) those *Volvox* species with protoplasts connected by protoplasmic filaments, namely, *V. aureus*, *V. globator*, *V. perglobator*, and *V. rousseleti;* and (2) those without the interprotoplastic connecting filaments, namely, *V. spermatosphaera*, *V. tertius*, *V. africanus*, and *V. carteri* (*V. weismannia*). The species of the second group are more or less megalogonidiate, and it is those of this group that are more so with which *Campbellosphaera* is more closely allied. My present conception of the relationships of the Volvoceae is represented by fig. 1.

## SUMMARY

From fixed and living specimens collected near Manila, Philippine Islands, a new species of the Volvocaceae (subfamily Volvoceae), is described which I propose for the type of a new genus under the name *Campbellosphaera obversa.* A type specimen is described in detail and figured by photomicrographs. It exhibits the most peculiar character of the genus, which is migration of gonidia, formed early in the development of the embryo, from the outside to the inside of the embryo through the phialopore. The gonidia become very large before dividing. The somatic protoplasts lack protoplasmic connecting fibers.

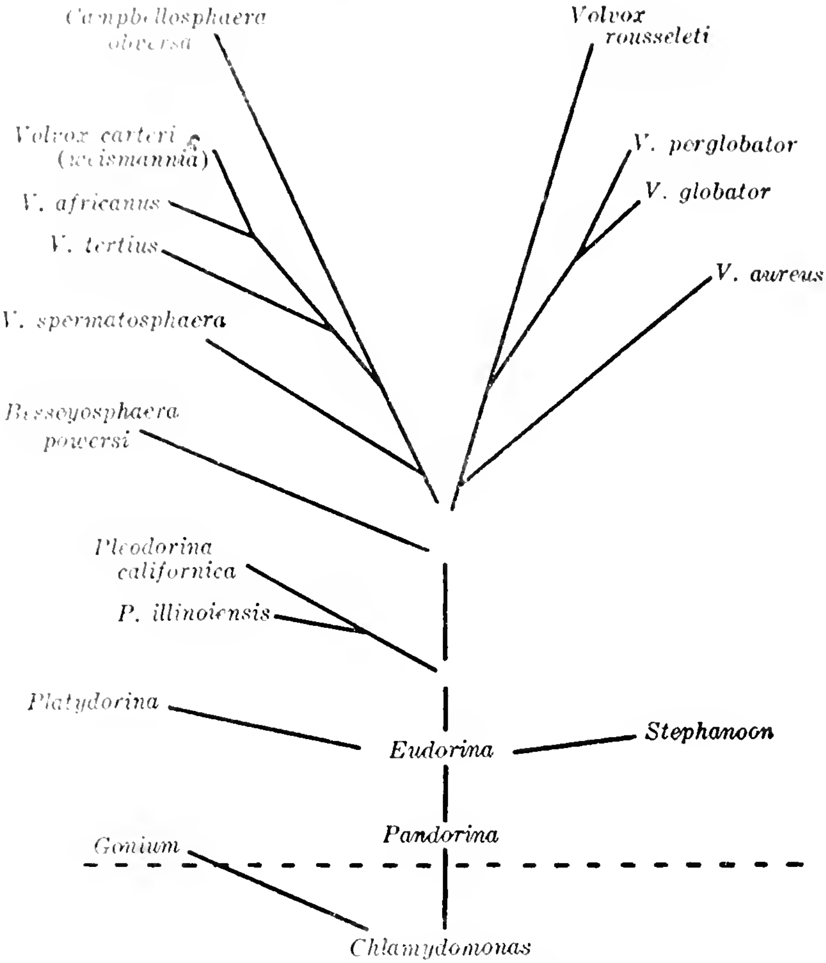



FIG. 1. Phylogeny of the Volvoceæ.

A series of specimens is described which supply the salient features of a rounded life history with asexual and sexual reproduction. Many details are left for future work and workers. The sexual coenobia are monoecious.

Formal diagnoses of the genus and species are followed by a comparison of the new genus with the recorded species of *Volvox* and closely related genera. Some existing synonomy is pointed out, reducing *V. weismannia* Powers to *V. carteri* Stein, and some future synonomy is foreshadowed.

*Volvox aureus* Ehrenberg is reported as having been collected in California in 1896. The specimens were found to agree closely with the ample description of the species by Klein ('89A and '90).

## LITERATURE CITED

CARTER, H. J. ('59). On fecundation in the two Volvoces, and their specific differences. *Ann. & Mag. Nat. Hist.* III **3** (1859) 1–20, *pl. 1.*

CHATTON, E. ('11). Pleodorina californica a Banyuls-sur-mer. Son cycle évolutif et sa signification phylogénique. *Bull. Sci. France et Belg.* VII **44** (1911) 309–331, *pl. 7.*

COHN, F. ('75). Die Entwickelungsgeschichte der Gattung Volvox. *Festschr. z. Gopperts 50 jährig. Doktorjubiläum.* Breslau (1875) 34 pp., *1 col. pl.*

EHRENBERG, C. G. ('38). Die Infusionsthiere als vollkommene Organismen. Berlin and Leipzig (1838). (Not seen).

JANET, C. ('12). Le Volvox. Limoges (1912) 151 pp.

JANET, C. ('14). Note préliminaire sur l'oeuf du Volvox globator. Limoges (1914) 12 pp.

KLEIN, L. ('89A). Morphologische und biologische Studien über die Gattung Volvox. *Jahrb. f. wiss. Bot.* **20** (1889) 133–211, *pls. 10–12.*

KLEIN, L. ('89B). Neue Beiträge zur Kenntniss der Gattung Volvox. *Ber. d. deutschen bot. Ges.* **7** (1889) 42–53, *pl. 3.*

KLEIN, L. ('90). Vergl. Untersuchungen über Morphologie und Biologie der Fortpflanzung bei der Gattung Volvox. *Ber. d. naturf. Ges. Freiburg i. B.* **5** (1890) 92 pp., *pls. 2–6.*

KOFOID, C. A. ('98). On Pleodorina illinoisensis, a new species from the plankton of the Illinois River. *Bull. Ill. State Lab. Nat. Hist.* **5** (1898) 273–293, *pls. 36 and 37.*

MERTON, H. ('08). Ueber den Bau und die Fortpflanzung von Pleodorina illinoisensis Kofoid. *Zeitschr. f. wiss. Zool.* **90** (1908) 445–477, *pls. 27 and 28, 1 Col.*

MEYER, A. ('95). Ueber den Bau von Volvox aureus Ehrenb. und Volvox globator Ehrenb. *Bot. Centralbl.* **63** (1895).

MEYER, A. ('96). Die Plasmaverbindung und die Membranen von Volvox, mit Rücksicht auf die thierischen Zellen. *Bot. Zeit.* **54** [1] (1896) 187–217, *pl. 8.*

OVERTON, E. ('89). Beitrag zur Kenntniss der Gattung Volvox. *Bot. Centralbl.* **39** (1889) 39 pp., *4 pls.*

POWERS, J. H. ('07). New forms of Volvox. *Trans. Am. Microscop. Soc.* **27** (1907) 123–149, *pls. 11–14.*

POWERS, J. H. ('08). Further studies in Volvox, with descriptions of three new species. *Trans. Am. Microscop. Soc.* **28** (1908) 141–175, *pls. 23–26.*

SHAW, W. R. ('94). Pleodorina, a new genus of the Volvocineae. *Bot. Gaz.* **19** (1894) 279–283, *pl. 27.*

SHAW, W. R. ('16). Besseyosphaera, a new genus of the Volvocaceae. *Bot. Gaz.* **61** (1916) 253 and 254.

STEIN, F. ('78). Der Organimus der Infusionsthiere. Leipzig (1878) **3** [1] 134.

WEST, G. S. ('10). Some new African species of Volvox. *Jour. Quekett Mic. Club* II **11** (1910) 99–104, *pl. 3.*

WEST, G. S. ('16). Algae. Cambridge (1916) 1 181.

# ILLUSTRATIONS

[Photomicrographs of *Campbellosphaera obversa* Shaw, from specimens mounted in Venetian turpentine, taken by W. R. Shaw and E. Cortes at the Bureau of Science, Manila.]

PLATE I

FIG. 1. Type specimen containing three gonidia, two closing bowl embryos with their gonidia migrating inward, and two bullet embryos of which the gonidia form a close cluster within each closed phialopore. × 200.

2. The same specimen with less magnification and more depth of focus. × 100.

3. A coenobium containing two gonidia and five embryos with a foreign body in the background simulating an additional embryo. The lower embryo on the right side is the oldest, the upper one on the same side being the youngest. × 100.

4. A nearly mature mother coenobium containing seven asexual daughters, in each of which there are from six to eight gonidia. × 100.

5. An asexual coenobium containing four gonidia and two young embryos. × 100.

6. A nearly mature sexual coenobium between two young asexual coenobia. The sexual coenobium shows dark oogonia and lighter oospores, of which there are twenty-three in all. The asexual coenobia contain seven gonidia each. × 100.

7. A portion of the same coenobium photographed on a larger scale. It shows an oogonium, oospores, and somatic cells. A little above and to the left of the center of the figure is a young specimen of an endophytic alga occupying the angle between four somatic cells. × 400.

8. A younger sexual coenobium containing twelve oogonia and sixteen oospores. × 100.

9. A still younger sexual coenobium containing twenty-five oogonia and three antheridia. One of the latter lies near the middle of the right side and another is at the top of the same side. × about 200.

PLATE II

FIG. 10. A nearly mature asexual coenobium containing one asexual daughter with seven gonidia at the right side of the top, and six sexual daughters containing each from twenty-seven to thirty-one reproductive cells, more or less. × about 200.

11. An asexual coenobium containing, in addition to one gonidium and four asexual embryos, one sexual daughter (the lowermost embryo) with sixteen reproductive cells.

FIG. 12. A sexual coenobium between two asexual ones. The former contains fifteen reproductive cells, of which thirteen are oogonia and two are oospores. The asexual coenobium at the right contains seven gonidia; two pairs of larger ones in the posterior half of the coenobium (uppermost in the figure) and three smaller gonidia in the anterior half. The coenobium at the left contains two pairs of large gonidia in the posterior half, one smaller gonidium in the anterior half, and a still smaller anomalous cell like a gonidium at the posterior pole. × 100.

13. An asexual coenobium with seven embryos. It shows end and side views of bullet embryos, and a side view of a bowl embryo with the gonidia (8) obviously outside of the bowl. × 100.

14. An asexual coenobium with three pairs of gonidia. × 200.

15. An asexual coenobium with one gonidium and six embryos which are all in the bullet stage, the daughter gonidia being closely clustered about the posterior pole of the coenobial cavity. × 200.

16. The same coenobium in slightly different focus. × 100.

17. An asexual coenobium containing seven embryos, in each of which the gonidia have become separated. × 100.

TEXT FIGURE

FIG. 1. Phylogeny of the Volvoceae.

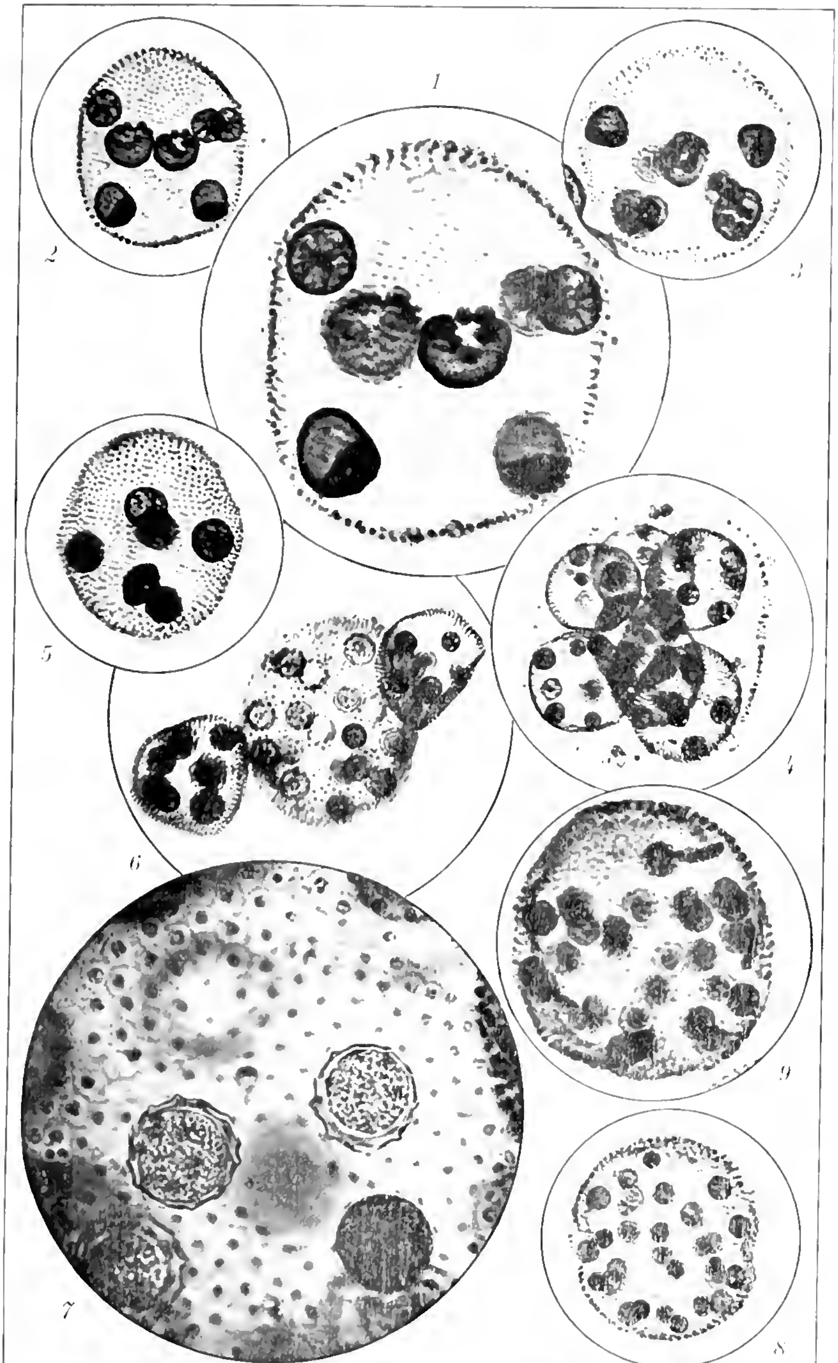



PLATE I. CAMPBELLOSPHAERA OBVERSA SHAW.

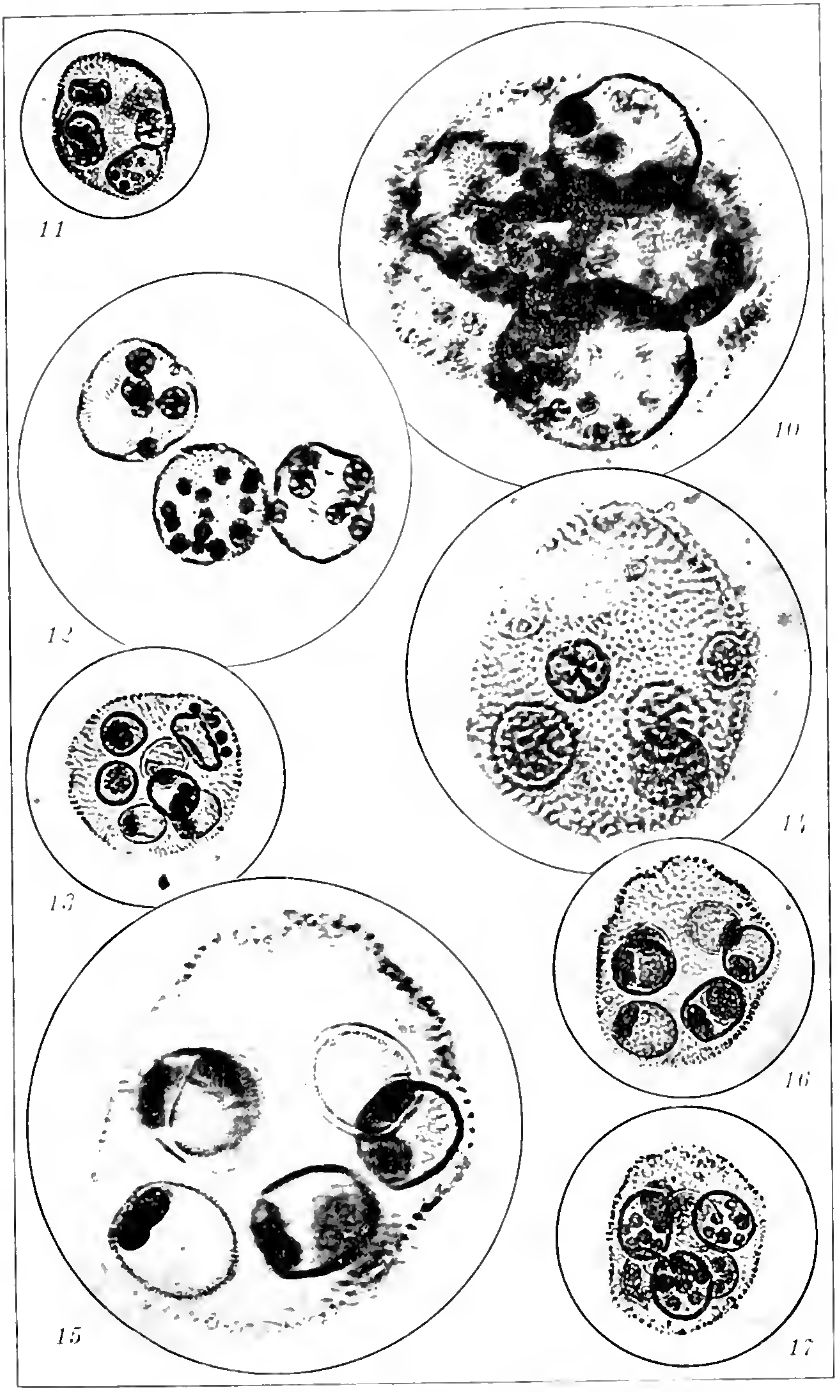



PLATE II. CAMPBELLOSPHAERA OBVERSA SHAW.

# SOME MALAYAN DELPHACIDÆ (HOMOPTERA)

By Frederick Muir

*Of the Hawaiian Sugar Planters' Experiment Station, Honolulu*

ONE PLATE

This paper deals with a few of the specimens of Delphacidæ recently collected by Prof. C. F. Baker. I hope in the near future to be able to report on the remainder of the collection.

The more I study this family the more I am convinced that the tibial spur must form the chief characteristic for the primary division, although it may appear to be, at times, more artificial than natural. Any other one character is still more unsatisfactory.

The types of the new species described in this paper are deposited in the collection of the Hawaiian Sugar Planters' Experiment Station, Honolulu, H. T., and the paratypes, when present, in the Baker collection.

## Genus PUROHITA Distant

Purohita nigripes sp. nov.

*Male.*—Macropterous; width of vertex at base slightly more than length, base slightly behind middle of eyes, twice width of apex; basal joint of antennæ 1.5 times the length of second.

Very light brown; apical half of face, genæ, and lateral margins of pronotum whitish, a dark brown line dividing the white lateral portion of pronotum from the rest, darker brown over abdominal tergites, a dark longitudinal mark on first and second femora, tarsi of those legs black or dark brown. Tegmina hyaline, slightly opaque, veins white with irregular black spots, a dark brown mark over cross veins, not quite reaching to inner margin and fading out toward apex; wings hyaline, slightly opaque, veins light brown.

Lateroventral edge of pygophor produced into a small, obtuse angular process; genital styles straight on inner margin and on outer margin for basal two-thirds, then tapering to the acute apex, which is curved outward.

Length, 3.5 millimeters; tegmen, 4.0.

*Female.*—Basal joint of antennæ slightly longer in proportion to the second (1 to 1.8); whitish mark over apical half of face and lateral margin of pronotum slightly greenish.

Length, 5.3 millimeters; tegmen, 5.7.

PENANG (*C. F. Baker, 9874*), 1 male and 1 female.

### Genus BAMBUSIBATUS Muir

**Bambusibatus albolineata** Muir.

BORNEO, Sandakan (*Baker, 9889*), 2 females.

### Genus TROPIDOCEPHALA Stål

*Tropidocephala* STÅL, Ofv. Vet. Ak. Forh. (1853) 266.

**Tropidocephala malayana** Matsumura.

*Tropidocephala malayana* MATSUMURA, Ann. Mus. Nat. Hung. 5 (1907), 64, pl. 2, figs. 5, 11.

PENANG, 1 male and 1 female. SINGAPORE, 1 male. (*Baker, 9851, 9852*).

The males are darker in color than the females, the apical veins and across the apical cells being fuscous. The male genitalia are very close to those of *T. dryas* (Kirk.).

### Genus BRACHYCRAERA Muir

**Brachycraera albolineata** Muir.

BORNEO, Sandakan (*Baker*), 2 specimens.

### Genus UPACHARA Distant

**Upachara straminea** sp. nov. Plate I, fig. 1.

*Female.*—Macropterous; head broader than thorax, width of vertex double the length, apex not or but very slightly produced in front of eyes and together with outer edges of eyes forming nearly a semicircle, base of vertex in front of middle of eyes, curved parallel to apex; carinæ faint, diamond cell obscure, basal cells 5-sided with a small depression in middle of each; face very little longer than broad (1 to 0.9), sides arcuate, median carina simple; antennæ small, not reaching base of clypeus, first joint about as long as wide, second joint twice the length of first. Pronotum as long as or slightly longer than vertex, faintly tricarinate, lateral carinæ strongly divergingly curved, not reaching hind margin, mesonotum faintly tricarinate. Hind tibiæ longer than tarsi, first tarsus subequal to other two together; spur not as long as first tarsus, small, cultrate, thick, a small tooth at apex but none on hind margin.

Stramineous; spines on hind legs black; tegmina hyaline, light stramineous, veins little darker; granules minute, sparse, with fine, black hairs.

Length, 2.7 millimeters; tegmen, 2.8.

PENANG (*Baker, 9862*), 1 female.

### Genus SOGATOPSIS Muir

**Sogatopsis pratti** Muir.

BORNEO, Sandakan (*Baker*), 1 female.

### Genus MALAXA Melichar

**Malaxa obtusipennis** sp. nov.

*Female.*—Macropterous; vertex longer than wide (1 to 0.8), base slightly wider than apex, diamond cell slightly before apex, apex very slightly curved, base slightly behind middle of eyes; length of face 2.7 times the width, slightly narrowed between eyes, sides straight, subparallel; antennæ reaching well beyond middle of clypeus, second joint twice the length of first. Tegmina with apex more obtuse than in the type species, but apical cells forming about one-half of tegmina.

Black, or deep, shiny, liver brown; antennæ, apex of clypeus, rostrum, legs, carinæ of vertex and pronotum, base of mesonotum and abdominal sternites light brown or yellow; ovipositor dark. Tegmina dark brown, clear hyaline at apex of clavus extending into corium, and at apex of costal cell and first two apical cells and apex of third apical cell, veins between them dark; veins dark brown; wings hyaline.

Length, 2.2 millimeters; tegmen, 2.8.

BORNEO, Sandakan (*Baker, 9894*), 3 females.

**Malaxa bakeri** sp. nov. Plate I, fig. 3.

*Male.*—Macropterous; length of vertex nearly equal to width at base (1 to 0.9), base situated considerably before middle of eyes, wider than apex, which is very slightly rounded; length of face 2.4 times width, slightly widened from base to apex, sides straight, median carina simple; antennæ reaching a little beyond base of clypeus, second joint 2.5 times the length of first; hind tibia slightly longer than tarsi, first tarsus subequal to the other two together. Tegmina long, apex subacute, apical cells forming half of tegmen (cross veins in middle of tegmen). Stramineous; slightly fuscous on pronotum between carinæ and on abdominal tergites. Tegmina hyaline, clear; longitudinal veins white; granules very minute with white hairs; cross veins

dark brown, forming a line from apex of clavus to middle of costa, broadening slightly toward costa; wings hyaline, veins white.

Pygophor very shallow, the diaphragm being nearly on a level with the rim, medioventral edge with a small spine curved to the left, anal segment with a single, large spine from the left side; genital styles narrow, long, with the apex produced into a curved, flat spine turned outward; ædeagus complex with a long curved spine on right side (not dissected out).

Length, 1.9 millimeters; tegmen, 2.6.

*Female.*—Macropterous; similar in coloration to the male.

Length, 2.5 millimeters; tegmen, 3.4.

LUZON, Bataan Province, Limay (*Baker, 10079*), 1 female; Laguna Province, Mount Maquiling (*Baker*), 1 female. SINGAPORE (*Baker*), 1 male. PENANG (*Baker*), 1 female.

The vertex is longer, the antennæ are shorter, and the tegmina are less acute than in the type species.

Malaxa javanensis sp. nov. Plate I, fig. 2.

*Male.*—Macropterous; base of vertex slightly wider than the length, considerably behind the middle of eye; length of face 2.2 times width, slightly widening toward apex, sides straight; antennæ reaching only to base of clypeus, second joint 2.4 times length of first; cross veins of tegmina at middle.

Yellow; lateral portions of pronotum, tegulæ, coxæ, and abdominal tergites dark brown. Basal half of tegmina brown, apical half hyaline, veins same color as membrane, granules very minute; wings hyaline with light brown veins.

Pygophor a little longer than broad, no spines on medioventral edge, anal segment with a large, curved spine on left side; genital styles asymmetrical at base.

Length, 1.5 millimeters; tegmen, 2.1.

JAVA, Pekalongan (*F. Muir*), 1 male.

Malaxa nigra sp. nov.

*Male.*—Macropterous; length of vertex slightly longer than width of base, base about middle of eyes, slightly broader than apex, which is slightly rounded; length of face 3.2 times width, slightly widened to apex, sides straight; antennæ reaching beyond middle of clypeus, second joint 2.8 times length of first; cross veins about middle of tegmina.

Head, thorax, coxæ, and abdomen very dark shiny brown or black, antennæ, legs, lower portion of genæ, carinæ of vertex, anal segment, and ventral aspect of pygofer yellowish. Teg-

mina black or very dark brown over basal half, hyaline over apical half, veins the same color as membrane, granules very small.

Pygophor slightly compressed laterally, medioventral edge with a single small spine; anal segment with a large spine from the left side; genital styles small, slightly curved, broadest at base, apex acute; ædeagus not visible externally and not dissected out.

Length, 1.5 millimeters; tegmen, 2.3.

*Female.*—Similar to the male.

Length, 1.7 millimeters; tegmen, 2.3.

LUZON, Bataan Province, Mount Limay (*Baker*), 1 male: Laguna Province, Mount Maquiling (*Baker*), 1 female.

## Genus ARCOFACIES Muir

*Arcofacies* MUIR, Canad. Ent. (1915) 261, 270, 320.

**Arcofacies penangensis** sp. nov.

*Male.*—Width of vertex at base double the length, base nearly double the width, of apex; length of face 1.5 times the width, sides slightly arcuate; antennæ not reaching base of clypeus, second joint 1.5 times length of first. In lateral view the clypeus at right angle to face, apex of face projecting slightly beyond clypeus; mesonotum considerably arched. Hind femora short, not reaching beyond apex of abdomen; tibiæ longer than femora, tarsi much shorter than tibiæ, first tarsus subequal in length to other two together, spur small, about as long as first tarsus, fairly broad, thick, a tooth at apex but none on hind margin. Tegmina acutely tectiform, compressed beyond apex of abdomen, costal margin shallowly emarginate beyond apex of abdomen, apex acute.

Ochraceous buff; hind legs slightly fuscous, abdomen bright yellow with a few, small, black spots on sternites, chestnut brown over pygophor and genital styles; tegmina chestnut brown, darkest over basal third, a clearer space along middle of costa at the emargination, a dark mark at apex of each apical vein, a small one at apex of claval vein, at fork of cubitus and fork of subcosta and radius, veins the same color as membrane, with numerous small, light granules.

Pygophor round with a small opening, no distinct dorsal emargination, anal segment short, exposed, without spines, anal style large, lanceolate; genital styles slightly curved, flattened, margins subparallel, apex truncate and produced into a quadrate process on inner margin.

Length, 2.1 millimeters; tegmen, 3.6.

*Female*.—Tegmina lighter than in male, abdomen ochraceous with a small black spot on each sternite, ovipositor same color as pygofer.

Length, 2.8 millimeters; tegmen, 4.4.

PENANG (*Baker*, *9880*), 1 male and 1 female.

Arcofacies fullawayi Muir.

SINGAPORE and PENANG (*Baker*, *9863*); previously known from the Philippines and Formosa.

Arcofacies insignis sp. nov.

*Female*.—Macropterous; width of base of vertex about double the length, base 1.7 times width of apex, diamond-shaped cell small but distinct; length of face 2.8 times width, sides straight, parallel, carinæ of head fairly prominent; antennæ reaching well beyond middle of clypeus, second joint very little longer than first; in lateral view clypeus strongly curved, apical portion at right angle to basal portion; hind femora short, not reaching to apex of abdomen; tibiæ longer than femora and much longer than tarsi, first tarsus subequal in length to the other two together. Tegmen similar in outline to that of type species.

Orange buff; slightly fuscous between carinæ of face and genæ, first antennal joint with two black, longitudinal marks, second joint mostly fuscous, lighter over carinæ of thorax; tibiæ with a black longitudinal line, ovipositor the same color as pygofer. Tegmina conspicuously marked with white and buff turning to light brown, some of the markings bordered with dark brown, the darker marking being over the basal two-thirds of costal cell, over basal portion of cubitus and media, marginal portion of clavus, over cross veins and spreading basad along cubitus and over apical portion of apical veins; veins light with light granules, most numerous on apical veins where they are irregular; wings hyaline with light veins.

Length, 3.3 millimeters; tegmen, 5.1.

LUZON, Mountain Province, Baguio (*Baker*), 1 female. This species is so distinct that I feel no confusion can arise by describing it from a female.

## Genus SOGATA Distant

*Sogata* DISTANT, Faun. Brit. Ind. Rhyn. 3 (1906) 471, fig. 258; MUIR, Can. Ent. 5 (1919) 8.

Sogata 4-spinosa sp. nov. Plate I, fig. 6.

*Male*.—Macropterous; head considerably narrower than pronotum; length of pronotum and mesonotum 1.5 times length of

head including eyes; length of vertex 1.7 times the width, carination as in *Delphacodes* Fieb., the Y carina obscure, base considerably behind middle of eyes; length of face 2.6 times the width, sides straight, slightly widened to apex; antennæ reaching slightly beyond base of clypeus, second joint 2.2 times length of first; first hind tarsus slightly longer than the other two together, tibial spur laminate with many small teeth on hind margin; lateral carinæ of pronotum straight, diverging posteriorly, reaching hind margin.

Light ochraceous, face between carinæ fuscous, nota laterad of outer carinæ darker; pleura, coxæ, and abdomen dark. Tegmina hyaline, inner half from base of clavus to apex of tegmen light brown, darker over area apical of cross veins, veins ochraceous with many fine granules bearing black hairs; wings hyaline, veins brown.

Opening of pygophor about as long as broad, dorsal emargination large, anal angles not produced; anal segment with two pairs of spines; outer pair short, broad, and slightly curved and wide apart at base; inner pair touching at base, long, narrow, and more basad than the outer pair; genital styles short, inner edge slightly concave, apex truncate with each angle slightly produced; ædeagus figured from left side with anal segment and pygofer.

Length, 1.7 millimeters; tegmen, 2.

SINGAPORE (*Baker*), 1 male. Described from one male. It is possible that this is the male of *S. dohertyi* Dist., but it differs enough to separate it. It is interesting in possessing two pairs of spines on the anal segment.

### Genus EUMETOPINA Breddin

*Eumetopina* BREDDIN, Deut. Ent. Zeit. (1896) 109.

**Eumetopina maculata** sp. nov. Plate I, fig. 7.

*Male.*—Macropterous; vertex slightly wider than long, base slightly wider than apex and situated slightly in front of middle of eye, apex rounded; length of face 1.3 times the width, slightly narrowed between eyes; antennæ reaching to near middle of clypeus, second joint three times length of first.

Ochraceous yellow, a fuscous mark on each side of median carina of pronotum, slightly fuscous over median portion of mesonotum, and a dark mark on each side just laterad of lateral carinæ; abdomen fuscous over tergites. Tegmina hyaline, very slightly ochraceous, veins darker, granules near together, minute, bearing light hairs; wings slightly ochraceous.

Pygophor with two minute spines close together on medioventral edge; anal segment with a single, median spine; genital styles small, narrow, slightly curved at apex; ædeagus with two spines on left side, the apical one larger and flat, the other furcate at apex, a large spine on right side at apex.

Length, 2.8 millimeters; tegmen, 3.

MINDANAO, Davao (*Baker, 10060*).

*Female*.—There are two specimens which I associate with the above male; namely, one from Imugan, Nueva Vizcaya, Luzon (the allotype), and one from Mount Limay, Luzon (*Baker, 9848*). They both have the pair of black marks on the mesonotum; otherwise they are ochraceous yellow.

This species is similar to *E. bakeri*, but the ædeagus is quite distinct.

**Eumetopina flava** sp. nov. Plate I, figs. 5*a*, *b*.

*Male*.—Macropterous; vertex about as long as broad at base, slightly narrowed to apex, which is slightly rounded; first joint of antennæ about half length of second; hind tarsi equal in length to hind tibiæ, first tarsus considerably longer than the other two together.

Light yellow; tegmina hyaline, very pale yellow, veins slightly darker, granules very minute, bearing light hairs.

Pygophor opening about as long as broad, a minute process on medioventral edge; anal segment with a single, median, curved spine on ventral edge; genital styles small, narrow, curved slightly at apex, which is pointed.

Length, 2.4 millimeters; tegmen, 3.

LUZON, Laguna Province, Mount Maquiling (*Baker, 9858*), 1 male.

**Eumetopina bakeri** sp. nov. Plate I, figs. 4*a*, *b*.

*Male*.—In build similar to *E. flava*. Light yellow, black over the middle portion of pronotum, mesonotum, and on metanotum and abdominal tergites.

Opening of pygophor about as deep as wide, two small processes on the medioventral edge; genital styles small, narrow, slightly curved at tip; ædeagus figured.

Length, 2.7 millimeters; tegmen, 3.

*Female*.—The female that I associate with this is all yellow like *E. flava*.

Length, 3.4 millimeters; tegmen, 3.6.

BORNEO, Sandakan (*Baker, 9892*).

### Genus PEREGRINUS Kirkaldy

**Peregrinus maidis** (Ashmead).

BORNEO, Sandakan (*Baker*), 1 specimen.

### Genus DICRANOTROPIS Fieber

**Dicranotropis pseudomaides** (Kirkaldy).

PENANG (*Baker*), 1 specimen. Previously known from Queensland.

### Genus STENOCRANUS Fieber

**Stenocranus (?) singaporensis** sp. nov. Plate I, fig. 8.

This species is congeneric with, and closely allied to, *S.* (?) *taiwanensis*.[1] For the present I place these two species in *Stenocranus* while recognizing that they will eventually have to be moved.

*Male.*—Macropterous; Mikado orange; tegulæ, middle of dorsum of abdomen and genital styles black.

Anal segment large, projecting considerably beyond pygofer, apex broadly rounded, pygofer very shallow, styles standing well out, a small spine on medioventral line. The apex of the genital styles differs considerably from *S. taiwanensis*. In the figure the right is shown more foreshortened than the left.

Length, 1.8 millimeters; tegmen, 2.3.

*Female.*—Macropterous. Similar to male in coloration.

Length, 2.3 millimeters; tegmen, 2.8.

SINGAPORE (*Baker*), 1 male and 1 female (type). PENANG (*Baker, 9865, 9867, 9868*), 1 male and 4 females. Some of the females do not have the tegulæ black.

[1] Proc. Hawaiian Ent. Soc. III 4: 323, pl. 6, fig. 44.

## ILLUSTRATIONS

### PLATE I

FIG. 1. *Upachara straminea* sp. nov., head, pronotum, and mesonotum, dorsal view.

2. *Malaxa javanensis* sp. nov., pygophor, full view.
3. *Malaxa bakeri* sp. nov., pygophor, full view.
4. *Eumetopina bakeri* sp. nov., ædeagus, *a*, lateral view, *b*, dorsal view.
5. *Eumetopina flava* sp. nov., ædeagus, *a*, lateral view; *b*, dorsal view.
6. *Sogata 4-spinosa* sp. nov., pygophor, lateral view.
7. *Eumetopina maculata* sp. nov., ædeagus, dorsal view.
8. *Stenocranus (?) singaporensis* sp. nov., pygofer, full view.

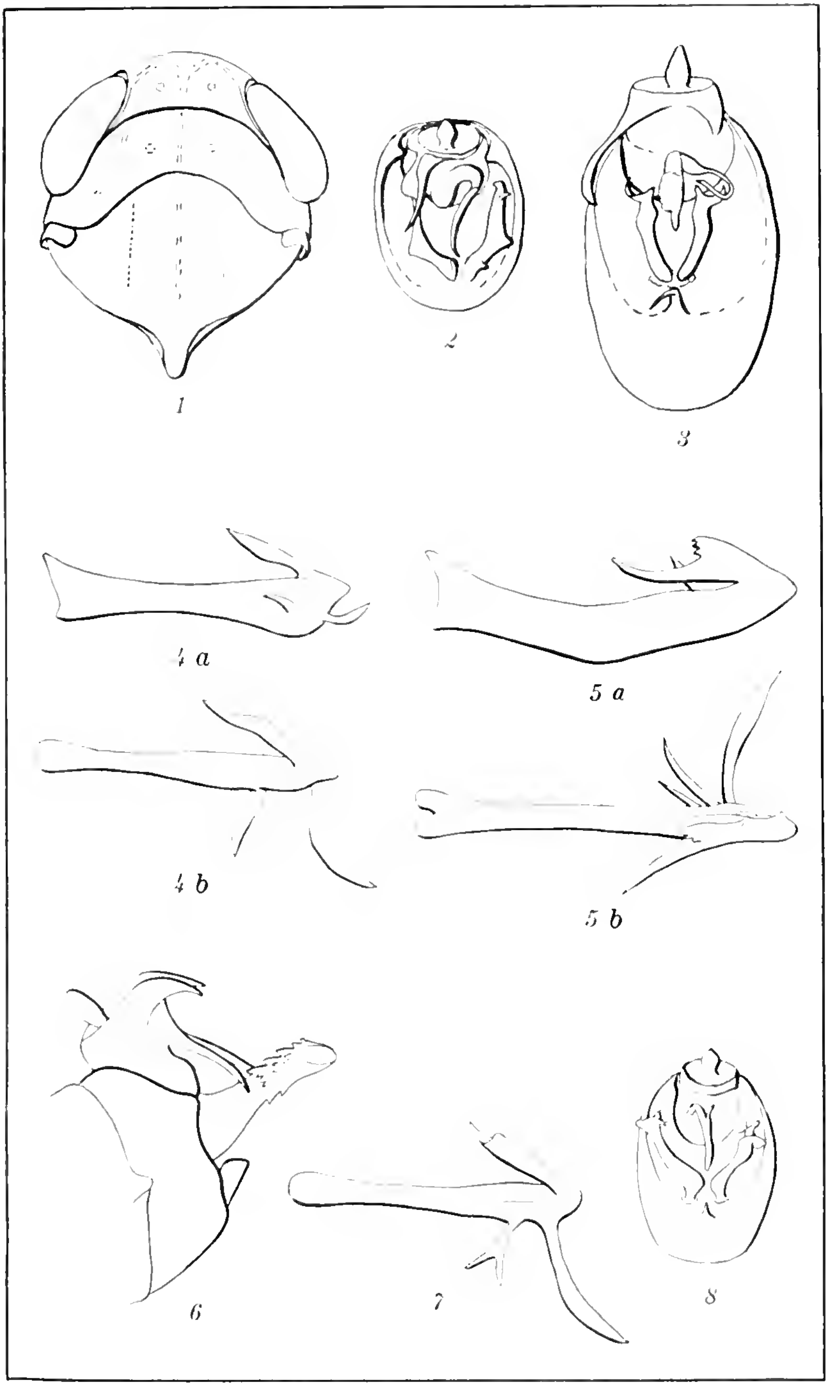



PLATE I. MALAYAN DELPHACIDÆ.

# A NESTING PLACE OF MICROPUS SUBFURCATUS IN MINDORO

By DEAN C. WORCESTER

*Of Cebu, Cebu, P. I.*

On May 13, 1919, having had occasion to explore the Caguray River, in Mindoro, I was resting in the shade of a great overhanging rock forming one side of the gap through which this stream finally leaves the mountains, when I noticed, only a few feet above my head, several nests of the common Asiatic barn swallow (*Hirundo javanica* Sparrman). Shortly afterward a carrier poked one of these nests down with a short stick, and from the resulting débris took two small birds, which on examination I found, to my surprise, to be young swifts. A moment afterward I saw a large, white-rumped swift enter the opening in the rock from which this nest had been removed. This bird flew away in a moment, but continued to return at frequent intervals, apparently puzzled by the loss of its young.

A more careful inspection of the underside of this overhanging rock showed, at a considerable distance above the ground, a series of grayish-colored nests, which blended so well with the rock that I had not previously noticed them. They gave the impression of being somewhat bottle-shaped, with the necks of the bottles usually directed inward toward the sloping face of the rock, the openings for entrance and egress being at the ends of the necks. In some instances there were merely round openings in the sides of the nests, and in two cases the nests were in holes in the rock, with their round openings directed outward.

By means of a long bamboo pole I succeeded in dislodging several nests. I found them to be composed almost exclusively of feathers, with which were intermingled a very limited number of bamboo leaves, a few other small leaves, and a very few blades of grass, the feathers having evidently belonged to a

great variety of wild birds. The nest materials were stuck together by the salivary-gland secretion of the birds, the cementing substance being plainly visible on the comparatively rough interior of the nest, but not in evidence on its outer side. The feathers were laid with their quill ends inward, their soft ends in many cases extending freely from the outer surface of the nest, so that the two sides of the nest presented strikingly different appearances.

Each of the nests dislodged contained two young nearly ready to fly. A specimen of an adult female sent to the Bureau of Science has been identified by Mr. R. C. McGregor as *Micropus subfurcatus* (Blyth).

# A METHOD FOR LABELING SLIDES USED IN ROUTINE STOOL EXAMINATIONS

By Frank G. Haughwout

*Of the Department of Parasitology, University of the Philippines*

ONE TEXT FIGURE

When large numbers of stools are examined, either in the course of routine clinical laboratory work or in research, the problem of numbering the slides used sometimes presents difficulties that may lead to confusion in recording the results. Various workers are accustomed to identify their slides by attaching to one end an ordinary gummed label, by etching the number or symbol on the glass with hydroflouric acid, by scratching it in with a diamond pencil, or by writing on it with a wax pencil. All these methods are troublesome in one way or another. Pasted labels are apt to absorb moisture and come off in the solutions, or they may become so discolored from the staining solutions that the figures become undecipherable; hydroflouric acid and the diamond pencil make a permanent record on the slide which may lead to confusion in another or the same series; figures written with a wax pencil are not always legible, they frequently come off in the solutions and, in a tropical laboratory where the temperature is constantly high, the lightest touch with the fingers transforms the record into a smudge.

No originality is claimed for the method which is here described. It is so simple and practical that it is difficult to believe that no other worker has thought of and applied it. Its essential feature is the ordinary wire paper clip (fig. 1, *a*) used to hold sheets of paper together, and which may be purchased of almost any stationer. The record is made on paper labels measuring 2.5 by 2.5 centimeters.

One end of the paper clip is slightly bent as shown in fig. 1, *b*, so that it will slip easily over the edge of the slide and yet hold the paper label firmly. A stock of clips with bent ends may be kept on the work table.

In operation the number or symbol is written with a lead pencil near the lower margin of the label which is then folded at the middle, hung over the end of the slide, and secured with the paper clip as shown in fig. 1, *c*. By this procedure about 1 centimeter of the label is exposed and the characters may be

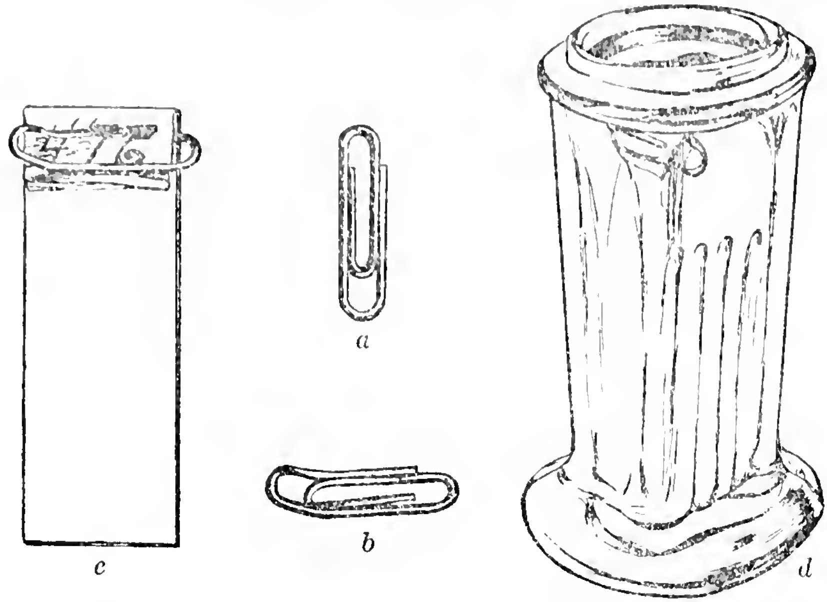



FIG. 1. *a*, paper clip as ordinarily employed; *b*, paper clip with one end bent over so it will pass easily over the surface of the slide; *c*, illustrating the method of applying the label to the slide; *d*, labeled slides in Coplin's staining jar.

easily read through the loop of the clip. The slides may then be stacked in the Coplin's staining jars, as illustrated in fig. 1, *d*, and manipulated in the usual manner. The margin of paper folded over the edge of the slide is so narrow that it will not become stained in the solutions and the slides may be washed in running water without risk of losing the labels. Slight pressure with the laboratory towel will remove any drops of water that may adhere to the clip and label after such an operation. When treatment of the preparation is completed, the clip may be detached, the paper torn across the sharp margin of the slide and the numbered end permanently attached to the slide with gum or paste. When the preparation is finally discarded the label comes off in the cleaning process and the slide is left without blemish. The clips do not interfere either with the proper stacking of the slides in the grooves of the staining jar or with the placing of the cover.

I have employed this method in making hundreds of preparations by the usual "wet" methods and have, so far, found no drawbacks to it. The clips are so cheap that when they become rusty, as they do in the course of time, they may be thrown away without any qualms of conscience.

In conclusion I desire to express my thanks to Miss Antonina Haughwout who drew the figures that accompany this note.

## ILLUSTRATION

### TEXT FIGURE

FIG. 1. *a*, paper clip as ordinarily employed; *b*, paper clip with one end bent over so it will pass easily over the surface of the slide; *c*, illustrating the method of applying the label to the slide; *d*, labeled slides in Coplin's staining jar.

# ADDITIONS TO THE FLORA OF GUAM

By E. D. MERRILL

*Botanist, Bureau of Science*

In 1914 I published an enumeration of the plants of Guam[1] in which about five hundred fifty species are included. Since that paper was published some additional collections have been made in Guam by Mr. Peter Nelson, of the Guam Experiment Station, and in the early part of 1918 a grant of 50 dollars was made to him from the income of the Robinson Memorial Fund of the New York Botanical Garden for the purpose of assisting him in the prosecution of field work in Guam. The arrangements under which this grant was made were that the material collected should be submitted to me for identification; one set to be retained for the herbarium of the Bureau of Science; one set to be returned to the Guam Experiment Station; and the remaining duplicate material to be transmitted to the New York Botanical Garden for distribution by that institution.

Shortly after the field work was commenced by Mr. Nelson, Guam was visited by an unusually severe typhoon, July 6, 1918, resulting in considerable damage to the equipment of the Agricultural Experiment Station there and in the destruction of the field outfit that had been provided for Mr. Nelson's botanical work, and a considerable amount of prepared botanical material. The field work was consequently delayed as several months elapsed before it was possible to replace the destroyed equipment. The collections already made have yielded several species and representatives of a few genera, new to Guam, as well as at least two undescribed species. These data have been incorporated in the present paper, together with a few changes in nomenclature.

## SCHIZAEACEAE

### SCHIZAEA Smith

SCHIZAEA DICHOTOMA (Linn.) Sm. in Mém. Acad. Turin 5 (1793) 422, *t. 9, f. 9.*

GUAM, *Nelson 221*, on tree trunks at Cotot, associated with *Psilotum nudum* Griseb. A widely distributed species in the Old World Tropics, the genus new to Guam.

[1] Philip. Journ. Sci. 9 (1914) Bot. 17–155.

## CYATHEACEAE

### CYATHEA Smith

CYATHEA HAENKEI (Presl) comb. nov.

*Alsophila haenkei* Presl Rel. Haenk. 1 (1825) 68.

*Cyathea marianna* Gaudich. Bot. Freyc. Voy. (1826) 265.

GUAM, *Nelson 538*, May, 1919, in ravines near the headwaters of a tributary to the Pago River.

The type of Presl's species was from the Marianne Islands, in all probability from Guam, while that of Gaudichaud was from Guam. Both have been reduced as synonyms of *Alsophila extensa* (Forst.) R. Br., which does not appear to me to be correct. Regarding the occurrence of this species in Guam I wrote to Mr. Nelson in September, 1914, supplying him with photographs of Philippine tree ferns, and suggested that he search for the Guam species, to which he replied that in his fourteen years residence in Guam, in which time he had visited most parts of the Island, he had never seen any tree ferns. A few specimens were located by him in May, 1919, apparently very old plants. The larger plants were about 3 m high, the trunk 15 to 20 cm in diameter below, tapering to 10 cm near the top. The species is apparently very rare and local in Guam and is probably approaching extinction.

## GRAMINEAE

### THUAREA Persoon

THUAREA INVOLUTA (Forst. f.) R. & S. Syst. 2 (1817) 782.

*Ischaemum involutum* Forst. f. Prodr. (1786) 73.

*Thuarea sarmentosa* Pers. Syn. 1 (1805) 110.

GUAM, Anigua, *Nelson 342*, December, 1919, along the seashore, local name *las-aga*. A common Malayan-Polynesian strand plant, but not previously recorded from Guam.

### GARNOTIA Brongniart

GARNOTIA STRICTA Brongn. in Bot. Duperry's Voy. (1829) 132, *t. 21.*

GUAM, hills back of Piti, *Nelson 359, 403*, December, 1918, and February, 1919. The genus is new to Guam, the species having been originally described from Tahiti, but now, as a somewhat variable one, known to extend from India, through Malaya to Hawaii.

### DIGITARIA Heister

DIGITARIA ROBINSONII sp. nov.

Species *D. pacificae* Stapf et *D. stenotaphrodi* Stapf affinis differt racemis numerosis, plerumque circiter 15, confertis, racemose dispositis.

A glabrous, erect, apparently tufted perennial grass up to 60 cm high. Leaves rather rigid, linear-lanceolate, 15 to 25 cm long, 5 to 8 mm wide, smooth, slenderly acuminate. Inflorescence exserted, composed of about 15, ascending, somewhat crowded, racemosely arranged spikes 6 to 12 cm in length, the axis of the inflorescence up to 4 cm long. Axis of the spikes about 1 mm wide, the spikelets numerous, oblong to oblong-lanceolate, about 2.5 mm long, alternate, in two rows. First glume obsolete or reduced to an oblong-lanceolate, somewhat hyaline, pilose scale less than 1 mm in length. Second glume somewhat pubescent, 5- or 7-nerved, usually acute, the margins somewhat inflexed over the flowering glume. Flowering glume lanceolate, glabrous, as long as the second empty glume.

GUAM, Cabras Island, *Nelson 520* (type) April 24, 1919, near the seashore. The same species is represented by *J. Guerrero 471*, collected on rocks at Anaw Point, July 26, 1916.

This species manifestly belongs in the small group of Polynesian ones discussed by Stapf following his description of *Digitaria pacifica* which includes *D. pacifica* Stapf, from Christmas Island; *D. stenotaphrodes* Stapf, which extends from the Caroline Islands to the Paumotu Archipelago; and *D. platycarpha* Stapf, from Bonin Islands. These species, as Stapf has indicated, form a well-marked natural group which seems to be peculiar to the Pacific islands. To this group may also be added *Digitaria mariannensis* Merr., the type of which was also from Cabras Island, Guam, but which differs radically from the other species mentioned above in its entirely different habit; in its small size; in its paired spikes; and in being ciliate-pilose. The group is well characterized by its very greatly reduced or obsolete first glume, the spikelets generally consisting of a single empty glume with the flowering glume and its palea. *Digitaria robinsonii* is well characterized in the group by its numerous spikes.

## CYPERACEAE

### SCLERIA Linnaeus

**SCLERIA LITHOSPERMA** (Linn.) Sw. Prodr. (1788) 18.

GUAM, Nasso River, *Nelson 308*, March 21, 1918, common along the banks of the river. A common pantropic species not previously recorded from Guam.

## COMMELINACEAE

### ANEILEMA R. Brown

ANEILEMA VITIENSE Seem. Fl. Vit. (1865) (73) 312, *t. 96*, var. PETIOLATA C. B. Clarke in DC. Monog. Phan. 3 (1881) 220.

GUAM, back of Sinajana, *Nelson 418*, January 1, 1919, in damp places at the base of limestone cliffs. The Philippines, Moluccas, and Polynesia.

## LEGUMINOSAE

### SERIANTHES Bentham

SERIANTHES NELSONII sp. nov.

Arbor alta, partibus junioribus et inflorescentiis et fructibus ferrugineo-pubescens; foliis circiter 20 cm longis, pinnis 12- ad 20-jugis, foliolis circiter 30-jugis, oblongis, obtusis, circiter 5 mm longis; floribus paucis, cylindraceis, breviter pedicellatis, corollae tubo circiter 12 mm longo, lobis lanceolatis, 5 ad 6 mm longis; leguminis circiter 12 cm longis, 2 ad 2.5 cm latis.

A large tree reaching a height of over 20 meters and a trunk diameter of nearly 2 meters, the younger parts, inflorescences, and fruits ferruginous-pubescent. Branches terete, grayish or brownish. Leaves up to 23 cm long, the petioles and rachis ferruginous-pubescent, the latter usually with a prominent gland between the bases of each pair of pinnae; pinnae 12 to 20 pairs, 5 to 7 cm long; leaflets 25 to 30 pairs, oblong, obtuse, about 5 mm long and 2 mm wide, the upper surface glabrous, the lower paler and sparingly pubescent. Flowers few, pink, their pedicels pubescent, stout, 2 mm long or less. Calyx cylindric, pubescent, about 7 mm long, the lobes ovate, acuminate, about 1.5 mm long. Corolla pubescent, cylindric, the tube about 12 mm long, the lobes lanceolate, acuminate, recurved, 5 to 6 mm long. Mature pods about 12 cm long, 2 to 2.5 cm wide, densely ferruginous-pubescent, the valves faintly constricted between the seeds, almost woody; seeds hard, shining, smooth, brown, flattened, elliptic, about 1 cm long, 8 mm wide.

GUAM, Upe District and hills back of Abu, *Nelson s. n., 23, 34, 240* (type), in flower in July and in fruit in December, local name *hayun lago.*

This very characteristic species is readily distinguishable in the genus by its small leaflets and its relatively narrow pods. It was originally collected in the Upe District, and regarding its occurrence there Mr. Nelson writes as follows:

The *hayun lago* is a very large and beautiful tree found at Upe at the northern end of the Island, and from what I could ascertain is

very scarce. The native name *hayun lago* means foreign wood, and would indicate that the tree is an introduced one in Guam. Few of the natives have ever seen the species. I saw two trees standing close together with trunks perhaps 6 feet in diameter, and a height of from 60 to 70 feet.

## EUPHORBIACEAE

### EUPHORBIA Linnaeus

EUPHORBIA MACGILLIVRAYI Boiss. in DC. Prodr. 15[2] (1862) 26.

GUAM, *Nelson 406*, December, 1918, on rocks along the Atautauo road.

The species has previously been reported only from Australia. It is also represented by *Volkens 102* (in part) from Yap, Caroline Islands, this number having been identified by Volkens as *Euphorbia serrulata* Reinw. My sheet of this number presents two distinct species; the softly pubescent one I here refer to Boissier's species, while the glabrous form may be a robust form of *Euphorbia serrulata* Reinw.

## STERCULIACEAE

### MELOCHIA Linnaeus

MELOCHIA VILLOSISSIMA (Presl) comb. nov.

*Riedleia villosissima* Presl Rel. Haenk. 2 (1835) 146.

*Melochia hirsutissima* Merr. in Philip. Journ. Sci. 9 (1914) Bot. 113.

GUAM, *McGregor 456* (type of *Melochia hirsutissima* Merr.), *Nelson 353*, in ravines back of Piti. October and December.

The type of *Riedleia villosissima* Presl was from Guam, but the species was overlooked by me in preparing the manuscript of my first paper on the Guam flora. Presl's description applies unmistakably to the species described by me as *Melochia hirsutissima*, the description apparently having been based on the uppermost and younger leaves.

## FLACOURTIACEAE

### XYLOSMA Forster f.

XYLOSMA NELSONII nom. nov.

*Flacourtia integrifolia* Merr. in Philip. Journ. Sci. 9 (1914) Bot. 115, non *Xylosma integrifolium* Clos.

GUAM, *Nelson 274, 322*, March and December, 1918; *Guam Experiment Station 466*, July, 1912.

Additional material with young fruits shows this species to belong in the genus *Xylosma* rather than in *Flacourtia* where it was originally placed.

## RUBIACEAE

### HEDYOTIS Linnaeus

**HEDYOTIS FRUTICULOSA** (Volk.) comb. nov.

*Oldenlandia fruticulosa* Volk. in Engl. Bot. Jahrb. 31 (1901) 475.

GUAM, *Nelson 268*, in small damp ravines at Santa Rosa, March, 1918. The third species of the genus from Guam, the specimen agreeing closely with *Volkens 72* and *171* from Yap, cotype material of the species.

### TIMONIUS (Rumph.) de Candolle

**TIMONIUS NITIDUS** (Bartl.) F.-Vill. Novis. App. Fl. Filip. (1880) 109.

*Petesia nitida* Bartl. in DC. Prodr. 4 (1830) 395.

The original description is short and was based on material collected by Haenke "in insulis Philippicis et Marianis." A part of the original collection is preserved in the Bernhardi herbarium at the Missouri Botanical Garden, an examination of which shows that the species is different from any of the rather numerous forms definitely known from the Philippines, but that this cotype material exactly matches several recent collections from Guam. I accordingly assume that the Philippine locality cited in the original description is erroneous and that the actual specimens came from Guam. It is represented by the following specimens: *Guerrero 762, Nelson 16, 138, 361,* collected at Behia, Masso, and near Piti, where it grows in thickets in ravines and along streams. The local names recorded are *sumac lada* and *maholoc layu.*

## COMPOSITAE

### BLUMEA de Candolle

**BLUMEA LACINIATA** (Roxb.) DC. Prodr. 5 (1836) 436.

GUAM, *Nelson 338*, in damp places near Abu, December, 1918. The second species of the genus to be found in Guam, doubtless introduced. Tropical Asia and Malaya.

# SEVENTH CONTRIBUTION TO THE COLEOPTERA FAUNA OF THE PHILIPPINES

By W. Schultze

*Of Manila, P. I.*

ONE PLATE AND ONE TEXT FIGURE

In this paper I wish to make known some species of Coleoptera from Surigao Province, Mindanao, and from the small islands Dinagat, Siargao, and Bucas Grande located off the northeastern shores of Mindanao. Comparatively little entomological collecting has been done in Mindanao and the smaller islands near it. The material herein described was collected by two of the Bureau of Science botanical collectors and my entomological collector, during the months of April, May, and June, 1919. The principal collecting was carried on in the vicinity of the town of Surigao. Several trips were made to a locality hereinafter called Iron Deposit. This region has been known for some time as a remarkable locality, geologically as well as botanically. It is located some 40 kilometers southeast of the town of Surigao near the settlement of Taganito. The soil at that locality is heavily charged with iron oxide, and in the near vicinity are also found deposits of coal, iron,[1] copper, and gold. Two remarkable pitcher plants are found there abundantly, at low and medium altitudes, these being *Nepenthes truncata* Macf. and *N. merrilliana* Macf., both being among the representatives of the genus with the largest pitchers known; a smaller species, *N. alata* Blanco, is also abundant. Five to six days were spent on each of the islands of Dinagat, Siargao, and Bucas Grande. A comparatively large number of species and specimens, considering the time spent there, was collected at all of the above-mentioned localities, due undoubtedly to the favorable season; during certain seasons of the year the last-mentioned islands are almost unreachable by boats, due to their being exposed to the full sweep of the monsoons across the Pacific. A very noteworthy feature among a number of species from the above localities is the fact that a species from Siargao, the larger island,

[1] Pratt, W. E., and Lednicky, V. E., Philip. Journ. Sci. § A 10 (1915) 335.

is represented or replaced on the smaller islands by a nearly related species or subspecies. In the case of the species, the close relation to the one from Mindanao or to that from the smaller islands is clearly observable, the characters based on the sculptural structure and the colored markings being similar to a greater or less degree, but sufficiently distinct to be considered as a separate species.

Among the species collected are a few long-known species, originally described as from the "Manillas" or just Philippines. The following are worth mentioning:

*Doliops geometrica* Waterh. from Surigao, Surigao, Mindanao. The specimens before me agree well with Westwood's [2] figure of this species.

*Doliops curculionoides* Waterh. from the same locality.

*Euchirus dupontianus* Burm. This species I recorded before from Baganga, Davao, Mindanao. Now Surigao and Bucas Island may be added. A male from the last-mentioned locality has the black lateral stripes on the elytra very faintly pronounced except near the shoulder where the same are expanded and spotlike. Length, 74 millimeters; width at shoulder, 32; length of anterior femur, 48; length of anterior tibia, 48.

Again, the question of mimicry suggests itself due to the very apparent superficial aspect on account of similarity in markings and patterns among a large number of species herein described.

The following species are herein described:

LONGICORNIA

*Euclea tagala* subsp. *rufofasciata* subsp. nov.
*Euclea siargaona* sp. nov.
*Acronia ? decimaculata* sp. nov.
*Doliops siargaoensis* sp. nov.

CURCULIONIDÆ

*Pachyrrhynchus virgatus* sp. nov.
*Pachyrrhynchus ardentius* sp. nov.
*Pachyrrhynchus absurdus* sp. nov.
*Pachyrrhynchus signatus* sp. nov.
*Metapocyrtus (Orthocyrtus) insulanus* sp. nov.
*Metapocyrtus (Orthocyrtus) malayanus* sp. nov.
*Metapocyrtus (Orthocyrtus) consobrinus* sp. nov.
*Metapocyrtus (Orthocyrtus) ornatus* sp. nov.
*Metapocyrtus violaceus* sp. nov.
*Metapocyrtus bucasanus* sp. nov.
*Metapocyrtus (Trachycyrtus) multisquamosus* sp. nov.
*Rhinoscapha merrilli* sp. nov.
*Alcides figuratus* sp. nov.
*Alcides adversarius* sp. nov.
*Alcides arenatus* sp. nov.
*Alcides plagiatus* sp. nov.

[2] Cab. of Orient. Entom. (1848) 60, pl. 29, fig. 6.

## LONGICORNIA

**Euclea tagala** Heller subsp. **rufofasciata** subsp. nov. Text fig. 1, *b*.

Shiny bluish black. The punctation less pronounced than in *E. tagala* Heller,[3] from Davao, Mindanao (text fig. 1, *c*). The markings very similar to those of the latter, except the fascia at the middle of the elytra which is narrow at the suture and extends to the lateral margin where it becomes expanded and spotlike, and from which a branch extends obliquely forward toward the scutellum. Only the middle fascia is white; all other markings are pale red.

Length, 18.5 millimeters; width, 5.8.

MINDANAO, Surigao Province, Surigao. Type in my collection.

FIG. 1. Three forms of *Euclea*; × 1.5. *a*, *Euclea siargaona* sp. nov.; *b*, *Euclea tagala* Heller subsp. *rufofasciata* subsp. nov.; *c*, *Euclea tagala* Heller.

A species related to *E. tagala* Heller is the following:

**Euclea siargaona** sp. nov. Text fig. 1, *a*.

Dark bluish black, less shiny than the preceding subspecies, all markings snow white. Front of head coarsely and irregularly punctured, with two large oblong spots, the area between the latter raised, forming a ridge. Another spot behind the eye. Vertex evenly punctured. Antenna bluish black, the basal third of the third joint and the basal half of the fourth white tomentose. Prothorax one-sixth broader than long. Rather densely punctured, the punctures small discally, but coarse toward the lateral margins. A broad anterior and posterior marginal band. Elytra densely punctured, the punctures near the base and toward the lateral margins very coarse. A stripe extending from the base near the shoulder obliquely to the lateral margin. A large subtriangular spot located just behind the scutellum at the suture, from which an oblique stripe extends on each elytron to the lateral margin, at which place this stripe

[3] Heller, Abh. Mus. Dresden 7 (1899) No. 8, 6.

becomes confluent with a band extending across the elytra slightly behind the middle. Parallel to the last-mentioned band, another at the apical fourth. Apical triangle with a large triangular spot. Underside, a spot laterally at the prothorax, mesothorax, and metathorax. First abdominal segment with a white marginal fringe, the following segments with a spot at the lateral margins.

Length, 18.6 millimeters; width, 6.

SIARGAO ISLAND. Type in my collection.

**Doliops siargaoensis** sp. nov. Plate I, fig. 11.

Dark brown, with a metallic greenish sheen and pale yellowish green tomentose markings. A medial stripe on head from the front to the vertex. Prothorax as long as broad, with an anterior and two posterior submarginal grooves. A narrow band slightly before the middle across the disk, from one lateral margin to the other. Elytra basally rather densely and coarsely punctured, the punctation toward the apex sparser and finer. A large suboval spot at the base. Slightly before the middle a combination of bands forming a triangle. At the apical third, one spot near the suture and another at the lateral margin. Posterior of each spot a short stripe, one subsutural and one submarginal not quite reaching each other at the apical triangle. Mesothorax and metathorax laterally with a large spot, also first abdominal segment. The following segments, except the last, each with a small spot laterally.

Length, 13 millimeters; shoulder width, 5.

SIARGAO ISLAND. Type in my collection.

**Acronia ? decimaculata** sp. nov. Plate I, fig. 17.

Shiny bluish black, with pale reddish brown tomentose spots. Front irregularly punctured, with a fine medial carina and an oblong bifid tomentose spot. The carina continued to the vertex, but as a fine groove. First joint of antenna sparsely punctured, third to eleventh joints black pubescent, the fourth joint with the basal half white tomentose. Prothorax longer than broad, impunctate discally, scatteredly punctured toward the lateral margins. An oval tomentose spot laterally near the posterior margin. Elytra sparsely and scatteredly punctured, the punctures coarser toward the middle, but toward the apex very small. The area at the middle very finely but densely black pubescent. Elytra with ten tomentose spots, two of which are located at the suture—a large one just behind the scutellum, the other at the apical fourth—and four on each elytron, two of these

at the lateral margin, one dorsally at the basal third, and the other at about the apical third. Margin at the apex white tomentose. Prosternum pale reddish tomentose, a large spot laterally on the mesosternum and the metasternum and a very large triangular spot laterally at the first abdominal segment. Fourth abdominal segment with a small spot laterally, and fifth with a large spot. Femora irregularly punctured, tibiæ and tarsi finely and densely black pubescent.

Length, 18 millimeters; width, at shoulder, 7.

MINDANAO, Surigao (my collector). Type in my collection.

I have placed this species provisionally in the above genus, with which it agrees in many characters; but on account of its longer legs it probably will have to be separated as soon as both sexes can be examined.

## CURCULIONIDÆ

**Pachyrrhynchus virgatus** sp. nov. Plate I, fig. 1, ♀.

Shiny black, impunctate, except the rostrum. In general form similar to *P. venustus* Waterh., although somewhat stouter in build than the latter, with reddish golden spots, which are strongly opalescent if seen at a certain angle. Rostrum finely and scatteredly punctured, slightly divergent toward the apex, at the middle abruptly set off, the basal half with a broad depression and a fine medial line. Front with a large roundish spot, and a small squarish spot below the eye. Prothorax with a round spot laterally, at the middle between anterior and posterior margins, and another larger spot at the lateral margin. Each elytron with two large basal oval spots, one discally, the other laterally; three spots about the middle, one a round spot discally laterad, another more laterally, and a large oval spot at the lateral margin. A bifid round sutural spot beyond the middle and another smaller sutural spot at the apical fourth. Obliquely posteriorly, and laterad to the large sutural, another large round spot. Between this spot and the large oval spot at the lateral margin usually another small spot is present in the female. Another spot near the lateral margin at the apical triangle. In some specimens a very small spot is located posterior to the discal basal spot. Apical sutural termination of the elytra not obtusely pointed as in *P. venustus* Waterh.

Male, length, 17.5 millimeters; width, 6.5. Female, length, 18 millimeters; width, 7.8.

MINDANAO, Surigao Province, Surigao (my collector). Types in my collection.

Specimens were also collected on Dinagat Island, and these show no appreciable variation from those from Surigao. However, the species was not collected on Siargao and Bucas Islands, but it appears as if the above species is replaced or represented in the last-mentioned islands by a form which I shall designate as

**Pachyrrhynchus virgatus subsp. insulanus subsp. nov.**

Uniformly shiny black, without any spots or markings. In general form, stouter in build than *P. virgatus*, and the elytra appear more inflated and more broadly rounded apically.

SIARGAO and BUCAS ISLANDS (my collector).

A careful search made on numerous perfect specimens for traces of scales or spots resulted negatively.

**Pachyrrhynchus ardentius sp. nov.** Plate I, fig. 7, ♀.

Glossy, glowing, purplish red with pale green markings and spots. Rostrum as broad as long, a strongly pronounced cross groove at the middle, from which there extends to the front a shallow depression, the lateral edges of which are strongly raised. Front densely and finely punctured. Sides of head with a scale spot. Prothorax slightly broader than long, with a posterior submarginal groove. A small triangular scale spot at the middle laterad, and a large oblong patch at each lateral margin. Elytra with very faint traces of rows of punctures. Each elytron with the following markings: Three spots at the base, one of which, near the lateral margin, is large and oblong; at the middle a small spot discally and a band extending laterally; along the margin a large oblong spot, almost confluent with a small triangular spot at the apex; beyond the middle at the suture a small spot; another sutural spot near the apex. Between the last-mentioned spots, somewhat laterad, a long dash; and laterad of the latter two other spots. Femora with a scale spot apically below.

Length, 16.5 millimeters; width, 7.8.

SIARGAO ISLAND (my collector). Type in my collection.

The spots on the elytra in this species seem to vary, since in the above-described type, the only perfect specimen I received, the second basal spot on the left elytron is absent.

**Pachyrrhynchus absurdus sp. nov.** Plate I, figs. 3, 3*a*, ♀; fig. 4, ♂.

Dark, glossy, glowing red, with bands of pale green scales. The sexes pronouncedly different from each other in general form and in markings on the prothorax. Rostrum sparsely punctured, with a strongly pronounced, oblong depression from the middle extending to the front, where it becomes shallow. The depres-

sion with an oblong pale green scale spot. Another spot at each side of head. Prothorax slightly broader than long, with an indistinct anterior submarginal groove and a strongly pronounced posterior submarginal groove. Male with two stripes discally, from the anterior to the posterior margin, which at the anterior margin are confluent, forming an arrow point. At the lateral margin another pair of stripes forming an irregular oval. Female with a pair of subparallel bands across the disk, from one lateral margin to the other. Elytra of male oval, one-fourth longer than broad, at the apex rounded; of female one-half longer than broad, apically terminating in a prolonged thorn, which is slightly bent downward. Elytra in both sexes punctate-striate. Female with two pairs of subparallel bands across the disk from one lateral margin to the other, and at the apical third another band forming a triangle. The basal pair of bands interrupted at the suture but confluent along the lateral margin. The anterior and posterior bands of the second pair are curved backward at and near the lateral margin, and they recurve so as to form the triangular figure apically. In the male the basal pair of bands is confluent subsuturally, forming an irregular, oval figure. A scale spot on each femur near the apex, below. Posterior femora of female not reaching beyond the apex of the elytra; in the male reaching well beyond the latter.

Male, length, 12 millimeters; width, 5.5. Female, length, 15.8 millimeters; width, 6.8.

BUCAS ISLAND (my collector). Types in my collection. This species was also collected on Dinagat and Siargao Islands. The markings on the prothorax discally are variable, particularly in the male, being sometimes broader. This species is truly remarkable on account of the great differentiation between the characters of the sexes, and of the first occurrence of its kind in the genus *Pachyrrhynchus*.

**Pachyrrhynchus signatus** sp. nov. Plate I, fig. 6, 6*a*.

Dark, glossy, iridescent, violet purplish with pale green markings, rostrum and legs metallic copper colored. Closely related to *P. erichsoni* Waterh. Head with a small scale spot under each eye. Prothorax with a narrow anterior marginal band, another somewhat broader band at the middle interrupted discally, and traces of a posterior marginal band. Elytra with rows of distinct punctures. Each elytron with two large oblong-oval spots near the base, one located discally, the other at the lateral margin; at the middle a crossband, reaching from the first row of punctures to the eighth near the lateral margin.

At the apical third a longitudinal stripe, at the third interstice, reaching to the apex, recurving as a submarginal stripe, thus forming roughly a triangle, inside of which are located two oblong spots at the fifth and seventh interstices, respectively.

Length, 11.6 millimeters; width, 5.5.

SIARGAO ISLAND (my collector). Type in my collection.

**Metapocyrtus (Orthocyrtus) insulanus** sp. nov. Plate I, fig. 8, ♀.

Shiny black, with pale greenish yellow markings. Rostrum densely and confluently punctured, with an indistinct shallow depression and a squarish scale spot. Prothorax slightly broader than long, scatteredly and coarsely punctured, and with a posterior submarginal groove. A narrow anterior and posterior marginal band and an oblong spot at the middle extending toward each lateral margin. A large patch at lateral margin, confluent with anterior and posterior marginal bands. Elytra irregularly striate-punctate, the punctures somewhat coarser in the male. Each elytron with the following markings: Two basal spots, one discal and the other, a larger one, at the lateral margin; at the middle, a band which is more or less interrupted so as to form a cross row of spots; at about the apical third another cross row of three squarish spots, and laterad of the last mentioned two long dashes; along the lateral margin a long stripe which expands into a triangular spot at the apex; between the latter and the last-mentioned cross row of three spots, a subsutural dash. Femora with an irregular scale spot apically. Posterior femora of the female not reaching to the apex of the elytra; of the male, reaching beyond.

Male: Length, 14 millimeters; width, 5.8. Female: Length, 15.8 millimeters; width, 6.5.

SIARGAO ISLAND (my collector). Types in my collection.

Numerous specimens of this species were collected in Siargao Island and they seem to vary very little; however, the species was not found on Bucas nor on Dinagat.

**Metapocyrtus (Orthocyrtus) malayanus** sp. nov. Plate I, fig. 2, ♀.

Related to *O. schönherri* Waterh.; black, with pale greenish, metallic scale spots. Rostrum irregularly and confluently punctured; a cross groove at the base, and at the basal half a medial groove, which extends to the front. The latter sparsely and scatteredly punctured. Prothorax rather coarsely, irregularly confluently punctured, an anterior and posterior submarginal groove, and a fine medial groove which disappears some distance

from the posterior margin. At the anterior margin a narrow band of scales, at the middle laterad a roundish scale spot, and another oblong spot at the lateral margin. Elytra irregularly punctured in rows. The punctation similar to that in *O. schönherri* but somewhat denser. Each elytron with the following spots: Two at the base, one dorsally, the other at the lateral margin. At the middle a cross row of two spots, one dorsally, the other laterally. An oblong spot at the lateral margin. At the apical half a series of four or five spots; one of which, dorsally, has a tendency to become bifid, and two smaller spots between the latter and the oblong marginal spot. A subsutural spot is sometimes present, located posteriorly to the bifid spot. Another spot at the apical triangle. Mesosternum and metasternum with a spot laterally. Abdominal segments sparsely and scatteredly setose, more pronounced in the male. Femora with a scale spot near the apex, sparsely punctured and setose, tibiæ more pronouncedly setose. Femora of the male reaching beyond the apex of the elytra.

Male, length, 14.5 millimeters; width, 6. Female, length, 15.5 millimeters; width, 7.

MINDANAO, Surigao and Iron Deposit (my collector). Types in my collection.

Several specimens collected on Dinagat differ from the above, in as much as the punctures on the prothorax are still more confluent, almost coriaceous; in one specimen the spots are nearly absent. No specimens were collected on Siargao Island. This species is easily distinguished from *O. schönherri* Waterh., which I received from Paracale, Ambos Camarines Province, Luzon, by its smaller size, different sculpture—particularly on the prothorax—and smaller spots. The second cross row of spots on each elytron consists of only two in *malayanus* but three in *schönherri*.

From Bucas Grande Island numerous specimens were received, which represent a rather distinct local form of the above species and which I shall designate as

**Metapocyrtus (Orthocyrtus)** subsp. atratus subsp. nov.

Entirely glossy black, punctures on the rostrum, prothorax, and elytra sparser and less pronounced.

None of the specimens shows any trace of scales. The subsp. *atratus* represents a parallel to *Pachyrrhynchus virgatus* subsp. *insulanus* subsp. nov., together with which it was collected from the same plants.

**Metapocyrtus (Orthocyrtus) consobrinus** sp. nov. Plate I, fig. 5, ♀.

Black with pale green scale markings. Related to *O. malayanus* sp. nov. Rostrum densely confluently punctured. At the base a broad, rather indistinct depression, with a scale spot, not separated by a well-defined cross groove from the front, the depression extending to the latter. Front with an indistinct medial groove, scatteredly punctured, the punctures finer toward the vertex. Prothorax broader than long, greatest width before the middle, strongly coriaceous, with anterior and posterior submarginal groove. A narrow band at the anterior and posterior margins, interrupted at the middle. A small roundish scale spot toward each lateral margin and a large oblong spot at each lateral margin. Elytra punctured in irregular rows, the punctures denser and much coarser than in *O. malayanus*. Each elytron with the following spots: Three oblong spots at the base, one located dorsally, and two at the lateral margin. A cross row of three spots at the middle, having a tendency to form a band; an oblong spot at the lateral margin; at the apical third three spots, two of which are elongated dashes; another slender, dash-like spot subsuturally, and an oblong spot at the apical triangle. Lateral margins apically sparsely setose. Underside and legs irregularly sparsely punctured and rugose and sparsely setose.

Male, length, 13.3 millimeters; width, 5.6. Female, length, 14.8 millimeters; width, 6.8.

MINDANAO, Surigao, Iron Deposit (my collector). Types in my collection.

This species is easily distinguished from *O. malayanus* by its smaller size and the different sculpture, particularly of the prothorax.

*Metapocyrtus consobrinus* seems to be very variable as far as the spots are concerned. Among the material collected are some specimens which are uniformly black.

The males of this species, as well as of *malayanus* and other related species of *Orthocyrtus*, are easily differentiated from the females by the following characters: The elytra of the females are longer and much more inflated dorsolaterally than in the males; since the prothorax in both sexes is relatively subequal, the males show a much slenderer aspect. In species of the subgenus *Orthocyrtus* the posterior femora of the males extend beyond the apex of the elytra, whereas in the subgenus *Homa-*

*locyrtus*[4] the reverse is the case; that is, the posterior femora of the female extend beyond the apex of the elytra.

**Metapocyrtus (Orthocyrtus) ornatus** sp. nov. Plate I, fig. 12, ♂.

Black with pale green and golden scale markings. Rostrum strongly coriaceous, an indistinct cross groove at the base. Basal half of the rostrum with a large, squarish, shallow depression extending to the front, bearing an irregular spot of reddish golden scales. Front with a medial groove. Prothorax subglobular, coriaceous; an anterior and posterior submarginal groove; an anterior marginal band of reddish golden scales. A medial groove bearing a scale stripe extending from near the anterior to near the posterior margin, toward each lateral margin a broader scale stripe, and at the lateral margin a large oblong spot. Elytra coarsely and rather densely punctured in irregular rows in the male; in the female the punctures are less pronounced and more regular. Each elytron with a broad irregular band at the base, spotlike and expanded near the suture. Another band at about the middle interrupted at the suture, and posterior of the latter another irregular band. The band at the middle confluent with a marginal stripe, which extends to the apical triangle and becomes confluent with a subsutural stripe. The posterior crossband, which terminates near the lateral margin, confluent with another shorter stripe at the apical third. Between the latter and the subsutural stripe two irregular spots. The black areas of the prothorax and elytra with scattered, purplish metallic scales. Legs sparsely and irregularly punctured, and rugose and sparsely setose. Scattered reddish metallic scales on the femora near the apex and on the tibiæ. Mesosternum and metasternum of the male with a patch of brown pubescence.

Male, length, 14.5 millimeters; width, 6.2. Female, length, 12 millimeters; width, 5.6.

DINAGAT ISLAND (my collector). Types in my collection.

Two other specimens from Siargao Island (male and female), the only ones collected, differ from the above in not having the dorsolateral stripes on the prothorax, but a roundish scale spot, located at the middle, between the anterior and posterior margins.

[4] Numerous specimens of several remarkable species of this difficult subgenus were collected from the different localities; these will be considered on another occasion.

**Metapocyrtus violaceus** sp. nov. Plate 1, figs. 9 and 9*a*, ♀.

Black, with a narrow anterior marginal line on the prothorax and a broad basal and postmedial fascia on the elytra, consisting of violet scales. The fascia in the female iridescent violet with a metallic luster. Rostrum irregularly punctured, abruptly set off at the base by a well-pronounced cross groove. A medial groove in the basal half which extends to the front. The latter with a few scattered scales. Prothorax slightly longer than broad, greatest width before the middle, strongly coriaceous in the female, less pronounced in the male. An anterior and posterior submarginal groove. Elytra of female coarsely, irregularly punctured near the suture, confluently toward the lateral margin. Besides the above indicated fascia the female has, at the middle of the lateral margin, an irregular scale spot. The elytra of the female posteriorly, laterally compressed, the posterior slope at the suture produced, the latter forming a distinct ridge. Elytra of the male coarsely punctured in fairly regular rows, posterior decline evenly rounded. Apically the margins in both sexes finely setose. Legs castaneous, sparsely punctured and finely setose.

Male, length, 12 millimeters; width, 4.5. Female, length, 13.5 millimeters; width, 5.3.

SIARGAO ISLAND (my collector). Types in my collection.

**Metapocyrtus bucasanus** sp. nov. Plate 1, fig. 10, ♀.

Black, with bluish white scattered scales. Head, prothorax, and elytra similar in form and sculpture to *M. violaceus* sp. nov. in both sexes, but in form stouter in build, particularly the female, the elytra of which are not compressed posteriorly laterally. Prothorax with an anterior marginal line, the lateral margins of the former with numerous scattered scales. Elytra also with scattered scales, which are condensed in certain places, apparently forming indistinct spots or patches, namely, in both sexes basally and at apical third; in the female two other small indistinct spots located at the middle, one subsuturally, the other at the lateral margin. Apically, the lateral margins as well as the suture finely setose. Legs castaneous, sparsely punctured, and finely setose.

Male, length, 12 millimeters; width, 4. Female, length 13.5 millimeters; width, 5.8.

BUCAS ISLAND (my collector). Types in my collection.

**Metapocyrtus (Trachycyrtus) multisquamosus** sp. nov. Plate I, fig. 13, ♀.

Black, with creamy white scales, rather uniformly scattered on the prothorax, but on the elytra arranged in irregular spots. Rostrum sparsely and irregularly punctured and scantily setose; at the base constricted and set off by a strongly pronounced cross groove. Basal half with a well-pronounced medial groove, continued to the front. Prothorax indistinctly variolosely punctured, its greatest width before the middle. Elytra of female with irregular rows of coarse punctures and numerous spots of scales, located mostly at the interstices; of male with more regular rows of very coarse punctures, the interstices forming distinct ridges. Legs irregularly and sparsely punctured and setose. Hind femora of female reaching well beyond apex of elytra; hind femora of male reaching about half the length of elytra, beyond apex of the latter.

Male, length, 9 millimeters; width, 3.8. Female, length, 11 millimeters; width, 4.8.

SIARGAO ISLAND (my collector). Types in my collection. Numerous specimens were collected, but only from the above locality.

**Rhinoscapha merrilli** sp. nov. Plate I, fig. 16, ♀.

Black, covered with scales of various shades of greenish colors. Rostrum and prothorax as well as legs light greenish blue. Lateral margins of prothorax, a large patch on each elytron basally, also apically along the lateral margin, light yellowish green. Underside very light green, opalescent. Rostrum densely and irregularly punctured, a smooth longitudinal ridge at the middle bare of scales. Antennal groove terminating just before eye. Antenna with the second funicular joint longest, club black. Prothorax densely and irregularly punctured, except a median stripe, the latter with a groove anteriorly. Each elytron with nine longitudinal ridges which are connected by irregular cross ridges, thus forming large and strongly pronounced, squarish depressions. At the base and near the lateral margins and apex the longitudinal ridges are less pronounced, the cross ridges are absent, thus forming a large irregular patch at the base and near the apex. The patches vary individually.

Male, length, 17.8 millimeters, with rostrum; width at shoulder, 5.5. Female, length 20.8 millimeters, with rostrum; width at shoulder, 6.8.

MINDANAO, Surigao, Iron Deposit (my collector). Types in my collection. This species was found feeding on *Loranthes longipedunculata* Merr., also a new species, and a genus new to the Philippine flora.

Several specimens of this species were collected on Biliran Island, near Leyte, by my friend R. C. McGregor. Since *R. merrilli* is the first species of this genus to become known from the Philippine Islands, I wish to call attention to Heller's [5] remarks concerning the range or locality distribution and expansion of *Rhinoscapha* in comparison with the expansion of the pachyrrhynchids.

**Alcides figuratus** sp. nov. Plate I, fig. 15.

Subcylindrical, black, with creamy white bands. Related to *A. catanduanensis* Schultze. Rostrum sparsely and irregularly punctured in the basal half. Front with a well-pronounced depression. Vertex of head very finely punctured. Prothorax strongly coriaceous. A broad anterior submarginal band, interrupted at the middle, extending to the prosternum; another posterior marginal band, also interrupted at the middle. Elytra striate-punctate, the punctures rather coarse, particularly at the basal half. A combination of bands forming the figure Λ extending from the suture behind the scutellum to before the middle and to the margin. Another crossband beyond the middle reaching from one lateral margin to the other, a short branch extending forward at the suture. Apical triangle with a V-shaped marking. Legs finely and sparsely punctured.

Length, 15.5 millimeters, without rostrum; width, 5.8.

DINAGAT ISLAND (my collector). Type in my collection.

Another nearly related species is the following:

**Alcides adversarius** sp. nov. Plate I, fig. 14.

Subcylindrical, shiny black, with creamy white bands. Prothorax irregularly punctured, the punctation toward the base and lateral margins gradually coarser and confluent. An anterior submarginal oblong spot laterally, and a band at the posterior margin, interrupted at the middle, expanded and spotlike discally, extending to the lateral margin. Elytra striate-punctate, the punctures much finer than in *A. figuratus*. At the basal half a crossband, which is spotlike and expanded at the suture and extends in a curve to the lateral margins. Beyond the middle another crossband, interrupted at the suture, ex-

[5] Philip. Journ. Sci. § D 7 (1912) 298.

tending in a slight curve also to the lateral margins. Apical triangle with a large V-shaped marking.

Length, 13.5 millimeters, without rostrum; width, 5.3.

SIARGAO ISLAND (my collector). Type in my collection.

Numerous specimens of this species were collected, but only from the above locality.

**Alcides arenatus** sp. nov.

Subcylindrical, very slender, reddish brown. Rostrum relatively short; densely, irregularly, and confluently punctured. Prothorax very coarsely granulose, except the anterior submarginal area, and sparsely tomentose. Elytra very regularly punctate-striate, the punctures very large and squarish, the interstices forming regular ridges. Legs rather coarsely and confluently punctured and sparsely tomentose.

Length, 11 millimeters, without rostrum; width, 3.5.

SIARGAO ISLAND (my collector). Type in my collection.

This interesting species is easily recognized among any of the other Philippine species of *Alcides* by its very slender structure, peculiar sculpture, and coloration.

**Alcides plagiatus** sp. nov. Plate 1, fig. 18.

Shiny black, with large creamy white spots. Rostrum with a fine groove in the basal half; dorsally sparsely and finely punctured, laterally coarsely. A shallow depression on the front, which bears a punctiform impression. Prothorax finely and regularly punctured, strongly and uniformly inflated dorsolaterally, near the anterior margin laterally constricted. At the constriction an oblong spot; another roundish spot located at the base laterad. Elytra very finely striate-punctate. Each elytron at the base with a depression reaching from the roundish and projecting scutellum to the humeral angle, the basal margin rounded, bent upward and slightly overlapping the prothorax. Another depression at the apical decline. Each elytron with the following spots: A large, suboval sutural spot at the base, another large roundish spot before the middle at the lateral margin, a roundish subsutural spot in the apical half, laterad of the latter a smaller roundish spot, and a V-shaped spot at the apical triangle. Prosternum, mesosternum, and metasternum creamy white; abdominal segment laterally with a series of creamy white spots.

Length, 16.5 millimeters, without rostrum; width, 6.5.

LUZON, Ilocos Norte Province, Mount Palimlim (my collector). Type in my collection.

This species seems to be related to *A. schuetzei* Schultze, but in general appearance it represents an intermediate form between the first and second group of Philippine *Alcides* species which I indicated in a former paper.[6]

ENTOMOLOGICAL REMARKS

A very recommendable contribution to the knowledge of the Coleoptera of the Philippines[7] has just come under observation. Since this author states in his paper, that the number of species of Philippine Anthribidæ has grown to more than 60, I wish to call attention to the fact that in my catalogue of Philippine Coleoptera[8] are recorded 67 species and subspecies; this number together with those of Doctor Heller brings the number up to nearly 100 species. My catalogue contains 2,449 species and subspecies of Philippine Coleoptera; an additional list of over 400 species has since accumulated, which will be published at a future date.

[6] Philip. Journ. Sci. § D **13** (1918) 269.

[7] Heller, K. M., Philippinische Anthribidæ, *Tidjsch. voor Entomol.* (Dresden) **61** (1918) 242. (February 15, 1919.)

[8] A Catalogue of Philippine Coleoptera. Manila (1915.)

# ILLUSTRATIONS

[Drawn by W. Schultze.]

## PLATE I

FIG. 1. *Pachyrrhynchus virgatus* sp. nov., female.
2. *Metapocyrtus (Orthocyrtus) malayanus* sp. nov., female.
3. *Pachyrrhynchus absurdus* sp. nov., female; 3*a*, lateral view, elytron, female.
4. *Pachyrrhynchus absurdus* sp. nov., male.
5. *Metapocyrtus (Orthocyrtus) consobrinus* sp. nov., female.
6. *Pachyrrhynchus signatus* sp. nov., female; 6*a*, lateral view.
7. *Pachyrrhynchus ardentius* sp. nov., female.
8. *Metapocyrtus (Orthocyrtus) insulanus* sp. nov., female.
9. *Metapocyrtus violaceus* sp. nov., female; 9*a*, lateral view, elytron.
10. *Metapocyrtus bucasanus* sp. nov., female.
11. *Doliops siargaoensis* sp. nov.
12. *Metapocyrtus (Orthocyrtus) ornatus* sp. nov., male.
13. *Metapocyrtus (Trachycyrtus) multisquamosus* sp. nov., female.
14. *Alcides adversarius* sp. nov.
15. *Alcides figuratus* sp. nov.
16. *Rhinoscapha merrilli* sp. nov., female.
17. *Acronia ? decimaculata* sp. nov.
18. *Alcides plegiatus* sp. nov.

### TEXT FIGURE

FIG. 1. Three forms of *Euclea*, × 1.5.
*a*, *Euclea siargaona* sp. nov.
*b*, *Euclea tagala* subsp. *rufofasciata* subsp. nov.
*c*, *Euclea tagala* Heller.

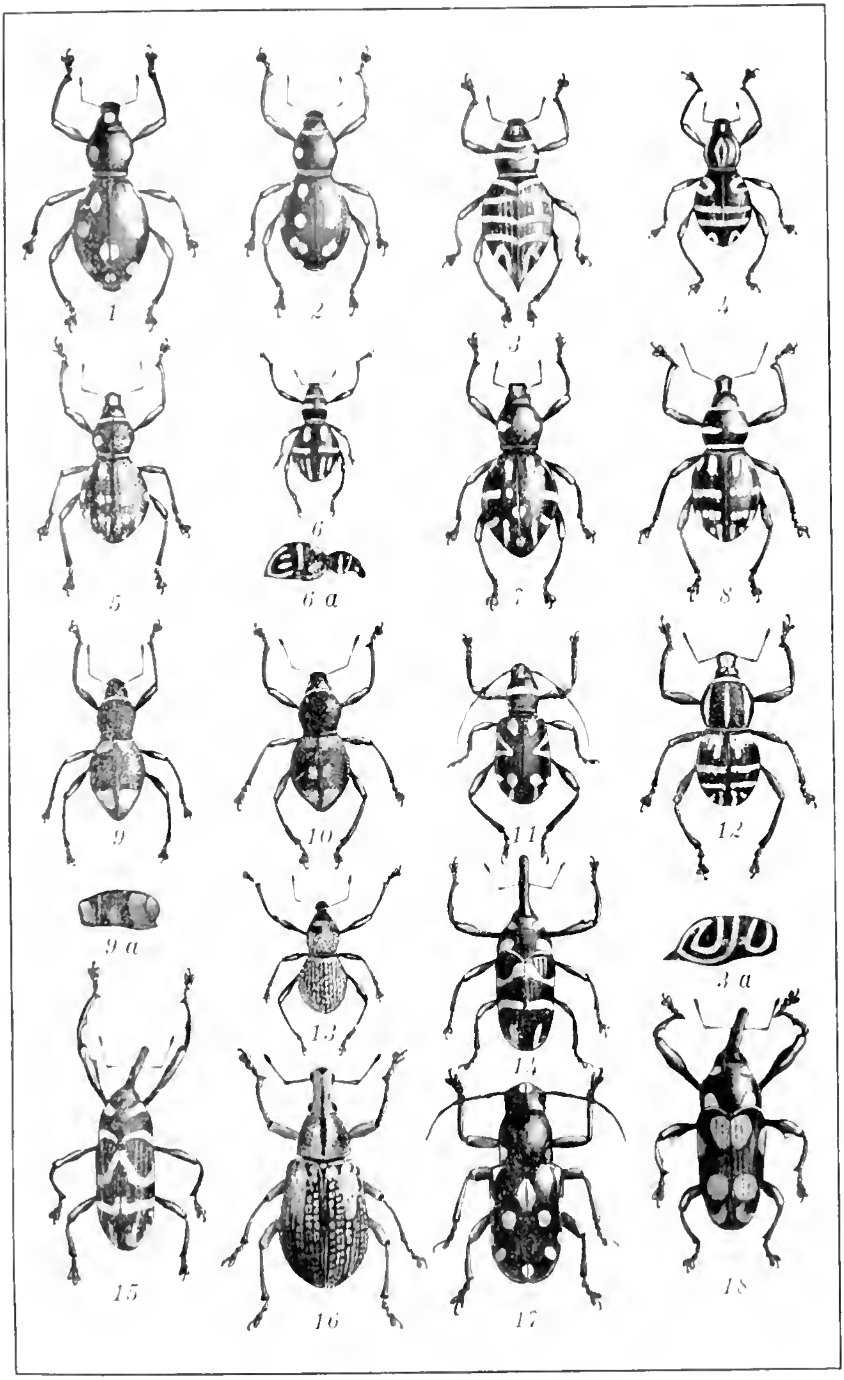


PLATE I. NEW PHILIPPINE COLEOPTERA.

# A CASE OF ACUTE MANIA ASSOCIATED WITH PLASMODIUM VIVAX INFECTION [1]

By Frank G. Haughwout, Pedro T. Lantin, and Ricardo Fernandez

*Of the University of the Philippines, and of the Philippine General Hospital*

ONE TEXT FIGURE

The case cited here is deemed worthy of note because it is one of the comparatively small number of cases recorded where infection with *Plasmodium vivax* has been associated with cerebral symptoms and death. Parasites were present in the peripheral circulation in small numbers only and the temperature of the patient at no time rose higher than 39° C., that point being reached a few hours before death. Prior to that time the fever did not rise above 38° C., this elevation coming several days after the onset of an acute mania.

The patient was one of a series of cases that was being experimentally treated with Roentgen rays for splenomegaly of malarial origin, the results of which work will be reported in another paper. He received only one irradiation, and that eight days before the development of the mental disturbance which ran its course and terminated in death eight days following its onset. At no time did the patient show any indication of injury that it seemed possible to trace to the Roentgen rays, and the necropsy failed to reveal any such evidence.

The subject was a male Filipino, 19 years old, unmarried, and a waiter by occupation. He was born in Iloilo and had resided in Manila for three months. About a year before his admission to the Philippine General Hospital he had gone to Davao where he had stayed for three months. During his stay in that place he had chills, fever, and headache every day during a period of almost two months. These symptoms recurred intermittently after his departure from Davao, and also continued following his arrival in Manila.

Physical examination made by Dr. Wenceslao Vitug of the house staff, showed the patient to be a poorly developed, poorly

[1] Contribution from the departments of parasitology and medicine, University of the Philippines and Philippine General Hospital.

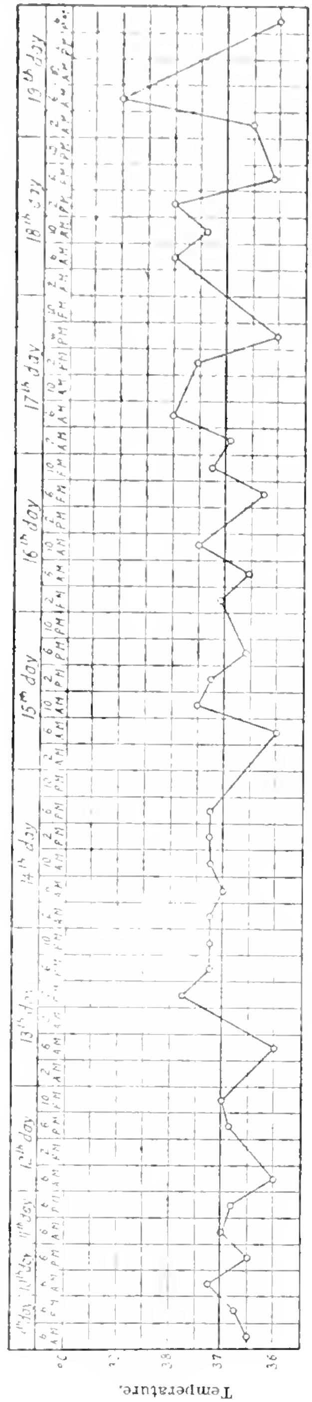


FIG. 1. Temperate chart of patient from ninth to nineteenth day.

nourished individual, pale and anæmic. The neck bore the scars of an operation for the removal of cervical glands. The lungs and the circulatory and digestive systems were apparently normal. There was marked splenomegaly, the lower margin of the spleen being traceable 10 centimeters below the left costal margin. The organ was hard and smooth to the touch.

Microscopic examination of the fæces revealed an infection with *Ancylostoma duodenale*. The urine was normal. Total erythrocyte count was 4,750,000. Hæmoglobin not estimated. The total leucocyte count was 9,200, the microscopist reporting "66 per cent polymorphonuclear neutrophiles, 26 per cent small lymphocytes, and 8 per cent eosinophiles." Examination of the blood later in the day by one of us (F. G. H.) failed to disclose any parasites. There was, however, an unusual amount of free pigment on the slide. While it is our practice to make note of such a finding, undue stress is not laid on it when the subject is a Filipino, or a member of another dark-skinned race.

The following morning, just before the patient was sent to the X-ray room, the blood was examined again, and one rather distorted parasite was found after a long search. The spleen was then irradiated, the procedure being as follows:

Coolidge tube.
Distance from targ. to skin, 30 centimeters.
Hardness of tube, 9B.
Milliamperes, 5.
Exposure, 5 minutes.
Filter, 2.5 millimeters, alum.; 7 millimeters of leather.
Hampson radio.
Area, entire spleen.

On the afternoon of the same day we again examined the blood of the patient, and noted an increase in the mononuclears, and stippling of the erythrocytes that had not previously been reported, but no more parasites were seen until the following day, when one was discovered that was provisionally identified as *Plasmodium vivax*.

Three days later there had been no apparent reduction in the size of the spleen. Blood examination showed a mononucleosis, an eosinophilia, and marked basophilic stippling of the erythrocytes.

The delirium developed suddenly four days after that. The patient first became restless and showed evidence of some mental distress. When inquiry was made as to what troubled him, he merely pointed to his scrotum without offering any explanation as to the nature of the trouble. He was carefully examined but nothing wrong was discovered. The restlessness increased, the eyes became bloodshot, and eventually his condition lapsed into one of noisy delirium that continued night and day except at such periods when he was under the influence of opiates. He shouted and sang and finally became so violent that he had to be tied into bed. The patient bit both tongue and lips and spat bloody saliva upon all who came near him. He presented a truly pitiable if not shocking spectacle. From this time on there was no change in the mental condition of the patient who virtually wore himself out in his tumultuous delirium. He refused all food and medicine, and his physical condition accordingly declined very rapidly. On the day of the development of the first mental symptoms an unmistakable trophozoite of *Plasmodium vivax* was found in the blood.

The number of parasites in the peripheral blood increased somewhat until from four to six could be counted in 100 oil-immersion fields. All were characteristic trophozoites of *Plasmodium vivax*. We failed to discover any of the questionable ring forms or any crescent gametocytes. The patient, who had been receiving iron, quinine, and strychnine up to the time his mania developed, was put on intramuscular injections of quinine

and urea, but he failed to show the slightest beneficial effects from them except for the disappearance of the parasites from the peripheral blood. Twenty-four hours before death adrenalin was administered in the hope of forcing the parasites out of the spleen and into the circulation, but without success. Three days before death the temperature, which had varied between the subnormal and the normal, rose to 38° C., and a few hours before death it reached 39° C. The day before death, the differential leucocyte count made by one of us (F. G. H.) showed 78 per cent polymorphonuclear neutrophiles, 7 per cent lymphocytes, 14 per cent large mononuclear leucocytes, and 1 per cent eosinophiles.[2]

The patient gave no history of previous attacks of mania, and the necropsy failed to disclose any evidence of syphilis. No Wassermann test was made.

## DISCUSSION

The case presented features that frankly puzzled us. In the literature available to us we can find no case that strictly parallels it. Our search for data in the literature has been somewhat complicated by the fact that many authors speak in general terms of cerebral symptoms complicating "tertian malaria" without specifying the species of parasite involved. The term is useful enough in a clinical sense, but many writers in recording results which may have to be considered by others seem to forget, for the time being, the well-known fact that tertian fever may be caused by infection with either *Plasmodium vivax* or *Plasmodium falciparum*.

We have, however, run across a few cases of recent occurrence in which the writers seem to have satisfied themselves of the occurrence of cerebral symptoms in so-called "benign" tertian fever. Among these will be found four cases reported from Macedonia by Wurtz and van Malleghem (5) and two by Hesse (2). In the report of Wurtz and van Malleghem, three of the patients developed violent delirium followed by unconsciousness; the other became cyanosed and unconscious following a period of vomiting. Both of Hesse's cases died. One developed acute cerebral symptoms which culminated in delirium on the fourth day; the other ran a course as a chronic relapsing meningitis. We have only been able to obtain these reports in abstract and therefore cannot thoroughly compare the cases. We are inclined

[2] The patient had received treatment with oil of chenopodium for his hookworm infection soon after entering the hospital.

to believe that all of them fell under treatment during the course of active malarial infection, while it must be borne in mind that ours was a chronic case showing no symptoms of active malaria. Wurtz and van Malleghem say they could find no parasite save *Plasmodium vivax;* while Hesse, according to the abstract, contents himself with speaking of his cases as being "benign" tertian, without naming the parasite. We are inclined to suspect that he was dealing with *Plasmodium falciparum* infections.

The possibility that the Roentgen rays in some manner precipitated the attack of mania might be borne in mind. We think this extremely unlikely unless their application operated to activate the parasite in some way—a thing that might possibly come to pass. However, in the short series of cases of chronic malaria that we have treated with the Roentgen rays, this is the only one that developed cerebral symptoms.

Skinner and Carson,(4) who first undertook the treatment of malaria with the Roentgen rays, report no such occurrence in their series; nor does Pais,(3) nor Deutsch,(1) who followed. Pais states his belief that new generations of the parasite appear to display exalted virulence under the influence of the rays. If this be true, we may have an explanation of the phenomena in our case, although it must be borne in mind that the parasites never were in the circulation in large numbers and that hyperpyrexia never developed.

Whatever the explanation of this strange case we can only repeat that painstaking search failed to disclose any evidence of infection with *Plasmodium falciparum,* while the parasites demonstrated in the circulating blood were unquestionably *Plasmodium vivax.*

## REFERENCES

1. Deutsch, Felix. Tiefelstrahlung der Milz bei Malaria. *Wien. klin. Woch.* **30** (1917) 207.
2. Hesse, Walter. Malaria Comatosa und Malariameningitis bei Tertianafieber. *Zentralbl. f. Innere Med.* **39** (1918) 385. Abstracted in *Trop. Dis. Bull.* 12 (1918) 351.
3. Pais, A. Influence of Roentgen rays on malaria. *Gazz. degli Ospedali e delle Clin. Milan.* **38** (1917) 1121.
4. Skinner, Bruce, and Carson, H. W. Curative influence of Roentgen rays in malaria. *Brit. Med. Journ.* No. 2617 (1917) 431.
5. Wurtz, R., and van Malleghem, R. Acces graves chez des paludeens atteints de tierce dite benigne. *C. R. Acad. Sci.* **164** (1917) 797. Abstracted in *Trop. Dis. Bull.* 11 (1918) 295.

# ILLUSTRATION

TEXT FIGURE

Fig. 1. Temperature chart of the patient infected with *Plasmodium vivax*.

# REVIEWS

Volume 2 New York Number Number 4 | The | Medical Clinics of North America January, 1919 Published bi-monthly by W. B. Saunders Company Philadelphia and London.

CONTENTS



Volume 2 Baltimore Number Number 6 | The | Medical Clinics | of | North America | May, 1919 | Index Number | Published bi-monthly | by | W. B. Saunders Company | Philadelphia and London.

CONTENTS

Notes on the gastric signs and symptoms in diseases other than those of the stomach, by Thomas R. Brown.

Gastro-intestinal disturbances in metabolic diseases and diseases of the ductless glands, by John H. King.

The rôle of diet in treatment of digestive diseases, by E. H. Gaither.

Esophagoscopy as an aid in the diagnosis and treatment of esophageal disease, by Elmer B. Freeman.

The roentgenologic signs of joint lesions in children, by Frederick H. Baetjer.

Introductory remarks to a discussion of diabetes, by Louis Hamman.

Serous membrane tuberculosis, by Louis Hamman.

Auricular fibrillation, by Louis Hamman.

A case of multiple tuberculosis in childhood, by Allen K. Krause.

Barbed Wire Disease: | A Psychological Study | of the Prisoner of War | by | A. L. Vischer, | M. D. Basle, M. R. C. S. Eng. | translated from the German, with additions by the author | with an introductory chapter by S. A. Kinnier Wilson, | M. A., B. Sc., M. D. Ed., F. R. C. P. Lond. | and a frontispiece by | Miss E. Fortescue-Brickdale London: | John Bale, Sons & Danielsson, Ltd. | Oxford House | 83–91, Great Titchfield Street, W. 1 | 1919 | pp. 1–84.

Cerebrospinal Fluid | in Health and in Disease | by | Abraham Levinson, B. S., M. D. | [7 lines of titles] | with a foreword by | Ludvig Hektoen, M. D. | with fifty-six illustrations, including | five color plates | St. Louis | C. V. Mosby Company | 1919 | Cloth, pp. 1–231, including index.

FOREWORD

The author was kind enough to ask me if I would look over his manuscript and then tell him whether it seemed to me worthy of publication. Later, when I told him that in my opinion he had produced a valuable little book, he requested me to state the reasons for this favorable opinion in the form of a foreword. This I can do in a few brief statements.

In the first place, on reading the manuscript, I soon became aware that the author had come to his task with not only a large experience behind him in the examination by various methods of the cerebrospinal fluid as an aid in diagnosis, but with a highly creditable record in the scientific study of this fluid as well. Evidently he had been drawn to his work on the cerebrospinal fluid because of its attractiveness as a field of research, as well as on account of its importance in diagnosis.

It is to this happy combination of true philosophic interest and first-hand practical knowledge on the part of the author that the book owes its chief merit, namely, thoroughness and freshness in the parts dealing with fundamental problems, as well as in those dealing with practical matters. In the second place there could be no doubt in regard to the timeliness of a work of this

kind. Indeed it seemed to me that a definite want would be supplied; for, in spite of an increasing importance in medicine, there was as yet no comprehensive book on all phases of the cerebrospinal fluid.

FROM THE PREFACE

Cerebrospinal fluid is of great physiologic importance for various reasons. It is the clearest and most transparent of all the fluids of the body. It is clearer than blood, than bile, and even clearer than urine, and under normal conditions experiments may be made on it without fear of clot formation or color change. Furthermore, cerebrospinal fluid, like blood and urine, can be removed from the living body without injury to the system. This gives one the opportunity of working with processes in the living body—a distinct advantage over the study of dead tissue.

From the standpoint of pathology also, cerebrospinal fluid presents an exceptional opportunity for study. The slightest change in the color of the fluid, the smallest increase in the protein content or in the cell count, all of which are easily discernible, indicate the presence of a pathologic process. One is able to follow the course of disease throughout all stages by noting the various changes the cerebrospinal fluid undergoes from time to time. These changes may be manifested not only by the presence of the causative organisms themselves, but just as frequently by specific physical, chemical, cytologic and physicochemical processes. A close study of the changes in the cerebrospinal fluid under pathologic conditions throws light, not only on the specific diseases of the nervous system, but on the condition of other systems. One can readily see, therefore, how large is the scope for the study of cerebrospinal fluid.

16×743——6

# INDEX

[New generic and specific names and new combinations are printed in clarendon; synonyms and names of species incidentally mentioned in the text are printed in *italic*.]

**E**

## N

## T

U